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ORIGINAL ARTICLES.

I.—Flowing Wells and Sub-Surface Water in Kharga Oasis.

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WITH the exception of an article written by me for Sir William Willcocks and published in his "Nile in 1904,"[1] and a reference to the relations of the Eocene and Cretaceous in the oasis of Kharga in a paper read before the Geological Society in 1905,[2] nothing has, I believe, been published on the water-supply and geology of this district since Dr. Ball's report in 1900.[3]

Since my first acquaintance with the Libyan desert oases, where from time immemorial a considerable population (at the present day exceeding 30,000) has flourished, the origin of the underlying artesian water, on which the very existence of the inhabitants depends, has always appealed to me as one of the most interesting problems of Egyptian geology. It was not, however, until two years ago, when I took up more or less continued residence in the oases, that I was able to pay special attention to the subject and make a commencement of attacking the problem by undertaking a detailed study of the geology and water-supply of a definite district, the northern part of Kharga oasis.

Before proceeding to a description of the actual district in question it may be well to briefly remark on the chief characteristics of the surrounding country as a whole, a more detailed account of which I hope shortly to give in a separate publication.

The Libyan desert is the easternmost and most inhospitable portion of the Sahara, or Great Desert of Africa. On the north and east its boundaries are clearly defined by the Mediterranean Sea and the highly cultivated valley of the Nile; on the south it is bounded by the Darfur and Kordofan regions of the Egyptian Sudan; south-eastwards its limits may be regarded as coterminous with the elevated

[1] "The Oases and the Geology of the Nile Valley," being Chapter 5 of "The Nile in 1904," by Sir William Willcocks, K.C.M.G., Cairo, 1904.

[2] "The Relations of the Eocene and Cretaceous Systems in the Esna–Aswan Reach of the Nile Valley": Quart. Journ. Geol. Soc., vol. lxi (1905), pp. 667–678.

[3] "Kharga Oasis: its topography and geology": Egypt. Geol. Surv. Report, Cairo, 1900.

district of Tibesti, while on the east it stretches to the outlying oases of Fezzan and Tripoli. Its area is approximately equivalent to that of the British Isles.

Except for a narrow belt fringing the Mediterranean the region is practically rainless, so that unlike the more elevated deserts on the other side of the Nile, where the rains are of sufficiently frequent occurrence to maintain a water-supply in the isolated water-holes and valley springs, and to allow of the growth of a fairly permanent though scanty herbage in the more favoured areas, the greater portion of the Libyan desert is quite devoid of vegetation, and is uninhabited even by nomad tribes. The extreme barrenness of the region as a whole, however, is in great measure counterbalanced by a number of isolated highly fertile oases, in which there is a permanent resident population.

The chief groups of oases are the Siwan on the north, that of Kufra on the west, and the Egyptian, including the four large oases of Baharia, Farafra, Dakla, and Kharga, on the east.

The Egyptian oases occupy extensive depressions cut down nearly to sea-level through the generally horizontal rocks forming the Libyan desert plateaux. These depressions owe their origin in great measure to the differential effect of subaerial denudation acting on rock masses of varying hardness and composition. Variation in the original conditions of deposition has resulted in a preponderant development in some areas of soft argillaceous beds, and subsequent folding has raised these beds in some districts and depressed them in others. Wherever during the general denudation of the country these soft deposits have become exposed, weathering has proceeded at an increased rate and gradually produced deep and broad depressions separated by elevated plateaux.

Geological Sequence in Northern Kharga.

The geological succession (excluding Pleistocene and Recent superficial deposits) in the northern part of the oasis of Kharga, determined by actual measurement of the different stages exposed on the floor and in the cliffs of the depression, and from numerous bores put down within the last two years, is as follows:—

			Average thickness in metres.
Lower Eocene	Lower Libyan ... Passage Beds ...	1. Plateau Limestone ...	115
		2. Esna Shales and Marls	55
Upper Cretaceous	Danian	3. White Chalk	70
		4. Ash-grey Shales	
		5. Exogyra Beds	30
	Campanian (Nubian Series)	6. Phosphate Series	70
		7. Red Shales	50
		8. Surface-water sandstones	45
		9. Impermeable Grey Shales	75
		10. Artesian-water Sandstones	120
			630

See Map, Fig. 1, p. 51. The numbers 1–10 correspond with section (Fig. 2) given on p. 55.

For the Eocene limestone, which everywhere caps the plateau between the oasis and the Nile Valley and also the northern bounding

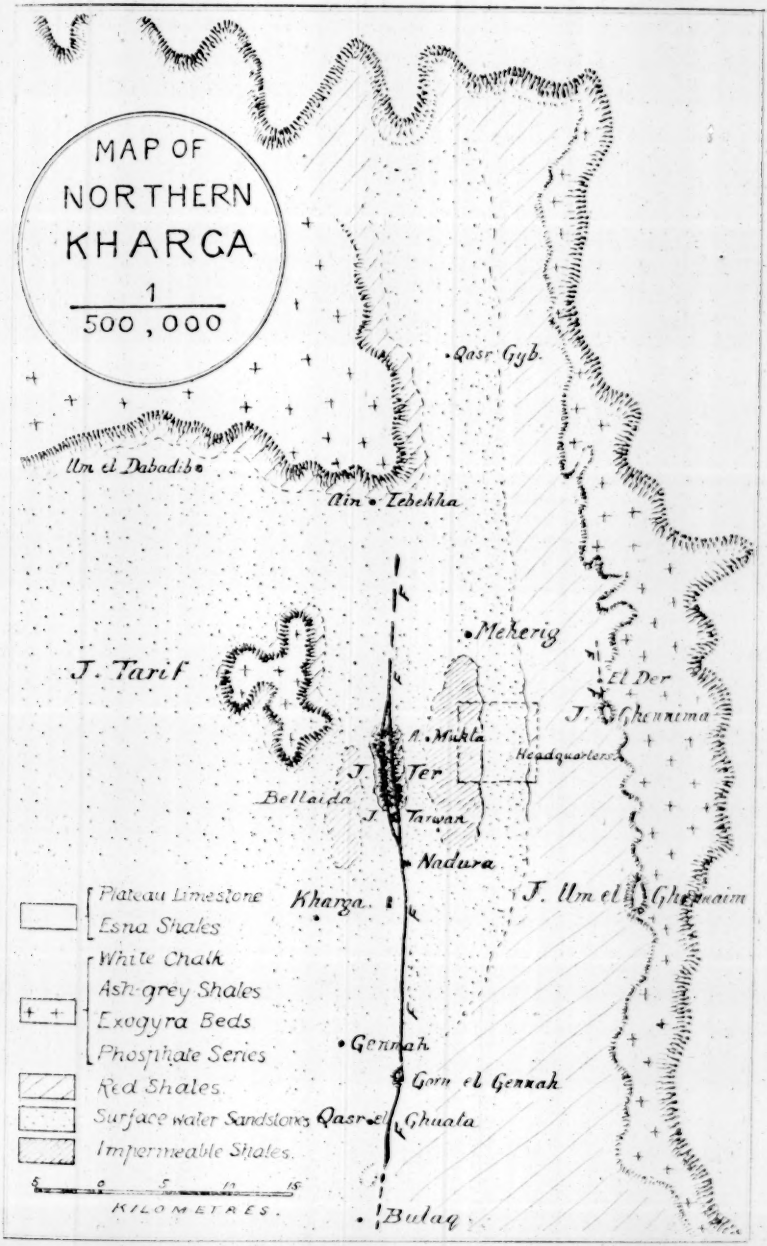
MAP OF
NORTHERN
KHARGA
1
500,000
Qasr Gyb.
Um el Dabadib
Ain Tebekha
Meherig
J. Tarif
El Der
J. Ghennima
Muhla
Headquarters
J. Ter
Bellaida
J. Tarwan
Nadura
Kharga
J. Um el Ghennaim
Plateau Limestone
Esna Shales
White Chalk
Ash-grey Shales
Exogyra Beds
Phosphate Series
Red Shales
Surface water Sandstone
Impermeable Shales.
0 5 10 15
KILOMETRES.
Genneh
Gorn el Genneh
Qasr el Ghuata
Bulaq

Fig. 1.

wall of the depression, I have adopted the convenient term of "Plateau Limestone." Between it and the White Chalk of the Upper Cretaceous come the Esna Shales and Marls, which, as I have shown in a former paper, are to be regarded as passage beds between the Cretaceous and Eocene systems.[1] It is true that in the lower layers fossils with typical Cretaceous affinities occur, but on the other hand forms of equally pronounced Eocene character are found in the upper bands. Lithologically there is nothing to distinguish one part of the band from another; typically it is made up of laminated shales, which by increase of carbonate of lime pass insensibly both upwards and downwards into the limestones above and below. The total thickness of the stage varies greatly in different parts of the oasis; this variation was regarded by Ball[2] as indicating an unconformity between the Eocene and Cretaceous, whereas it is due solely to the fact that varying thicknesses of the upper and lower portions become in places so markedly calcareous as to be indistinguishable from the limestones above and below. In some cases practically the whole, as a band of laminated shale, has disappeared, and then the Cretaceous limestones merge directly into those of the Eocene above.

Although the shales below the White Chalk differ little in colour from the Esna Shales above or from the shales of the *Exogyra* series below, I have retained Zittel's term "ash-grey shales"—though ash-grey is by no means their usual tint—to avoid the possibility of confusion. They are grouped most naturally with the White Chalk, which nearly everywhere forms a marked band at their summit; other less conspicuous bands of chalk or chalky marl sometimes occur intercalated in the shales on a lower horizon.

With regard to the *Exogyra* beds, it is only necessary to remark here that they are almost everywhere marked by hard bands made up of the shells of fossil oysters. Below comes a group of shales containing a number of prominent intercalated bands composed of fish-bones, coprolites, and phosphatic nodules; the series is so well marked in northern Kharga that it is difficult to understand how it had until recently escaped notice, yet that such was the case is evident, as Ball makes no mention of the beds in his report nor are they shown in the published sections. Considering the great development of phosphatic beds in the neighbouring oasis of Dakhla, the extension and thickness of which had been fully mapped and reported on by me in 1898,[3] it was no surprise to find similar beds in Kharga when I made a casual examination of the succession at one or two points in the early months of 1905. Since then I have traced the beds over a large area of northern Kharga, and found them to consist as a rule of an upper brown coloured series, individual beds of which in places exceed two metres in thickness, and a lower division consisting of three or four bands of harder and lighter-coloured rock, in which the nodules are sometimes cemented by iron pyrites. These bone-beds mark the

[1] Op. cit.: Q.J.G.S., vol. lxi (1905), p. 675.

[2] Op. cit., p. 94.

[3] "Dakhla Oasis: its topography and geology": Egypt. Geol. Surv. Report, Cairo, 1901.

invasion of the area by the Cretaceous sea, the underlying shales and sandstones being as far as known devoid of all fossil remains except vegetable impressions and silicified wood, having in all probability been accumulated in an immense inland lake.

Underlying the phosphates is a great thickness of an almost homogeneous red or purple shale, below which occurs the first water-bearing sandstone; this will presently be described in detail. Between this sandstone, which for purposes of easy reference I have designated the "surface-water sandstone," and the underground sandstone from which the flowing wells of the oasis derive their water, is a 75 metre band of grey shale or clay; it is this bed which forms the confining and impervious cover, and prevents the water in the beds below from reaching the surface except when provided with such means of escape as artificial boreholes. To all intents and purposes these shales are impermeable, at any rate over the district in question, and may therefore be referred to as the "impermeable grey shales." The upper layers of this division are visible on the floor of the depression in some parts of the oasis, notably in the Bellaida district west of Jebel Tĕr, and in the neighbourhood of Ain Mukta to the east of the same range. Their thickness has been determined from the results of about twenty bores put down on the area about midway between Jebel Tĕr and Jebel Ghennima near the eastern scarp of the depression.[1]

The Longitudinal Monoclinal Flexure.

Although over the Libyan desert as a whole the general dip of the different sedimentary deposits is steadily northwards, we find considerable local variations, especially in the oasis-depressions. In northern Kharga there is a difference of level of over 200 metres between the same beds on either side of the depression, the dip being in fact eastwards, as will be seen from the accompanying section across the oasis from the summit of Jebel Tarif to the top of the eastern plateau in the neighbourhood of El Dĕr. The dip appears to markedly decrease, if not die out altogether, on either side, and the structure of the area might therefore be regarded as a simple monocline were it not for the dominant line of disturbance which runs in a north and south direction along the centre of the oasis parallel to the longer axis of the depression. This line of folding and faulting is most marked in Jebel Tĕr, a hill range bounded by faults and formed of beds let down through a vertical distance of over a hundred metres. Southwards the line of disturbance—in some places a fault, in others a monoclinal fold—can be traced past Jebel Tarwan, Nadura, and Kharga village to the conspicuous highly inclined beds of Gorn el Gennah, and thence passed the old ruined temple known as Qasr el Ghuâta, immediately

[1] The localities referred to in this paper are shown on the accompanying map, p. 51, the topography of which is based on the maps of the Survey Departmental Report. The scale (1 : 500,000) is of course too small to show each division of the Eocene and Cretaceous, and the boundaries of such as are indicated must only be taken as approximate. On the Survey maps the names of the two prominent outliers of the plateau on the east side of the depression have their names reversed: the most northerly is Jebel el Ghennima, the other to the south Jebel Um el Ghennaim.

south of which the White Chalk is let down some 300 metres on to the floor-level of the oasis, it and the underlying shales being bent into an almost symmetrical oval basin or centroclinal fold. In all probability the isolated eminences near Bulâq, Gala, and Girm Meshim mark the prolongation of the line of fault southwards, and it may quite possibly continue throughout the depression.

The difference in level on either side of the line of disturbance is as a rule very marked, the floor of the depression on the downthrow side being very considerably lower than that on the west or upthrow side. As might be expected, the line of partial or complete fracture directly affects the water-supply, and one of the most noteworthy features of the country south of Jebel Têr is the grouping of all the most important wells near but on the upthrow side of the fault, in spite of the ground on this side being at a considerably higher level. Probably the sandstones rise gently to the west, in which case the underground flow in this neighbourhood may be from west to east, which would account for the best yields being obtained from bores put down near but to the west of the fault; on the other side, although the actual surface level is lower, the water-bearing sandstones occur at a deeper level, and possibly the line of fracture in great measure cuts off the supply.[1]

Ball reported that the most striking evidence of faulting in the oasis was between Jebel Têr and Jebel Tarif, but although the possibility of this fault being connected with and causing the tilted strata of the Gorn el Gennah is referred to, he finally appears to have abandoned this view, as his map shows the fault as extending over only a comparatively short distance lying midway between Jebel Têr and Jebel Tarif and running in a N.N.E. and S.S.W. direction. This misplacing of the line of fracture led Ball to believe that the majority of the wells were on the east or downthrow side of the fault, whereas, as I have shown, they are in reality on the opposite or west side, the actual line of flexure passing almost direct from Jebel Têr through the Gorn el Gennah.

Surface-water Sandstone.

The stratigraphical position of the beds of this division will be seen by reference to the section. They have an average thickness of 45 metres, and consist almost entirely of sandstones of varying degrees of coarseness, often highly ferruginous, and containing occasional beds of aluminium and magnesium sulphates. Bands of shale are met with here and there, but as a rule are confined to the upper and lower portions of the series. Members of the group outcrop on the nearly level floor of the oasis over large areas to the east of the line of disturbance, while to the west, where, as I have shown, the general elevation of the beds is higher, they form the foothills of Jebel Tarif, Jebel Têr, and the high cliffs which rise to the north of Um el Dabâdib and Ain Lebekha. Probably the sandstones which form the surface of the desert between Kharga and Dakhla and cover large areas to the south of these oases, also belong to this group.

[1] Op. cit., pp. 95–97.

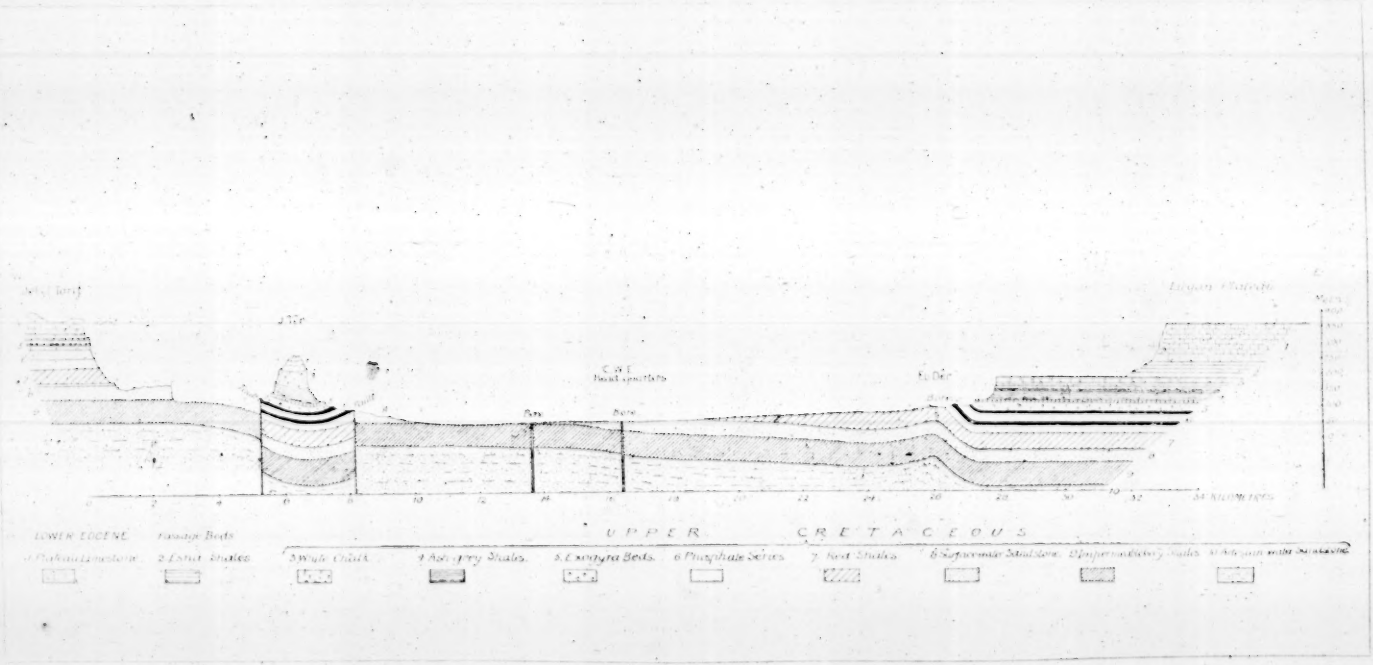

FIG. 2.—Kharga Oasis: detailed section across the Depression through Jebel Tarif, Jebel Tēr, C.W.E. Head-quarters, and El Dēr.

The sandstones of this series form the highest water-bearing horizon in the oasis, and one quite distinct from the artesian-water sandstone, the two being separated by a thick impervious series of dense grey shales. In the district round headquarters the water is as a rule met with at a depth of from five to six metres below the ground surface, is not under pressure, and does not rise appreciably in boreholes, so that to become available for irrigation it has to be lifted by power. An ordinary borehole or small pit is, however, useless, as the inflow of water through the pores of the sandstone is too slow to yield a pumping supply; in a large pit a number of small fissures are usually struck, and it is through these that most of the water is obtained. Provided a sufficiently large collecting tank is excavated—say 5 × 4 metres and sunk to from one to one and a half metres below the standing water-level—a supply sufficient to yield a continual discharge of eight gallons a minute (or 11,500 gallons per day of twenty-four hours) can usually be obtained. In especially favourable localities a pit of the dimensions given above will yield 15 or even 20 gallons per minute, and the pumping capacity can as a rule be still further increased by deepening. The extent to which this supply can be drawn on without appreciably lowering the water-level has not, of course, yet been determined, though in one pit alongside Bore No. 2, where a 'sâkia' has been working more or less continuously for over a year, the water-level has not appreciably changed.

Unfortunately the quality of this water, at any rate in the headquarters area,[1] is not uniform, in some places being quite sweet while in others, only a few hundred metres distant, it is highly ferruginous and more or less charged with salts. For instance, the water of a pit put down at a point 570 metres E.S.E. of headquarters was found on analysis to contain 63 grains of dissolved solids per gallon, the salts consisting of iron, potash, and soda, with traces of lime and magnesia, mostly in the form of sulphates and chlorides.[2] The utilisation of this water for purposes of irrigation would, at the rate of three gallons a minute per acre, mean an annual deposition of over three tons of sulphate of potash and common salt on each acre of land, an amount which would of course spell ruin to its agricultural value in a very short time.

In many parts of the oasis, however, perfectly sweet water is obtainable from the sandstones of this series, and that this source, as an auxiliary to the artesian supplies obtained from deep borings, was taken full advantage of by the ancients, is testified by the wonderful systems of underground aqueducts which penetrate the sandstones in many parts of the oasis, but more especially in the districts round Um el Dabâdib, Ain Lebekha, and Qasr Gyb. They were especially applicable to districts where the bulk of the sandstones, as in the first two localities mentioned, form extensive hills above the general level of the neighbouring cultivable ground. The method was probably

[1] The headquarters of the Corporation of Western Egypt, Ltd.; the area over which the boring operations referred to in this paper extend is shown on the accompanying map (Fig. 1, p. 51) by a dotted line.

[2] For the analyses quoted in this paper I am indebted to Mr. William Garsed, formerly of the Oasis Headquarters Staff.

introduced into the oases from Persia, where underground aqueducts or 'kareez,' for the transference of water from one locality to another, have from an early date been extensively employed. The immense amount of time and labour which must have been expended can hardly be realised without actually exploring the excavations themselves, but it may be remarked that at Um el Dabâdib the two main carrying channels, with their subsidiary branches, measure several kilometres in length, and are cut almost throughout in hard sandstone rock, the tunnels being moreover connected at frequent intervals with the ground surface above by vertical air shafts, likewise excavated in the solid rock; one of the latter which I descended measured 130 feet in depth.

It is difficult to believe that the supplies of water obtained from these sandstones were commensurate with the time and labour involved in the construction of the necessary collecting tunnels, but that enough water was obtained to enable fairly large colonies to exist is evident from the traces of former villages and cultivated areas. After the withdrawal of the Romans these outlying districts were abandoned and the subterranean aqueducts gradually silted up. Some few years ago one of the main tunnels at Um el Dabâdib was completely cleaned out, and when I visited the place in 1905 the discharge at the mouth of the aqueduct was about 30 or 35 gallons a minute.[1]

(*To be concluded in the March Number.*)

II.—Notes on the Geology of Basutoland.

By the Rev. S. S. Dornan.

THE rocks composing Basutoland belong to the Stormberg Series of the Karroo System. They cover a much larger area than Basutoland, extending into the Orange River Colony on the west and north, on the south and east into Cape Colony and Natal, and, I am informed, across the Vaal into the Transvaal. The area is thus not less than 45,000 square miles. The whole of that part of the Orange River Colony known as "the Conquered Territory," east of a line drawn from Thaba 'Nchu to Vrede, is occupied by the whole or portions of these rocks.

The average thickness of the rocks is as follows:—

	Designation.	*Thickness of feet.*
	Recent and superficial accumulations	20–40
Stormberg Series.	(1) Volcanic Beds	600–1000
	(2) Cave Sandstone	150–400
	(3) Red Beds	300–500
	(4) Molteno Beds (base not seen)	600 exposed.

[1] Bail visited the locality in 1898 before the tunnel described above had been cleaned out, and is responsible for the rather fantastic theory that it led to another inhabited oasis to the north of the escarpment (op. cit. pp. 31 and 76). The same writer further remarks (p. 82): "It is worthy of note that, with the exception of the Roman work near Ain Um Dabadib and a line of bricked manholes near Gennah, no traces of underground watercourses, such as occur so abundantly in Baharia Oasis, are to be seen in Kharga." As a matter of fact, however, there is hardly a district in northern Kharga where extensive underground aqueducts do not occur, and they far exceed in magnitude anything found in the oasis of Baharia.

The rocks are, as a rule, well exposed, owing to the great denudation the country has undergone. The thickness is very uniform all over the country from north to south, as at Qalo, near Botha-Bothe:

	feet.
Volcanic Beds	400
Cave Sandstone	250
Red Beds	350
Molteno Beds	450

and at Sebapala in the extreme south-east:

	feet.
Volcanic Beds	1000
Cave Sandstone	200
Red Beds	400
Molteno Beds	150 exposed in places.

As one advances farther into the hills the Volcanic Beds become much more prominent rock features, as they compose the highest ranges of mountains, termed Maluti in Sesuto. In addition to these rocks there is a vast network of intrusive sheets and dykes traversing the various members of the Stormberg Series.

(4) The Molteno Beds are composed of sandstones, shales, and mudstones, usually grey or greenish in colour, with occasional bands of conglomerate. When freshly fractured the sandstone presents a highly glittering appearance. Nodules of mud are of frequent occurrence, and most of the sandstone is of a loose texture. The rocks weather very fast. At Morija the shales contain numerous plant-remains referable to *Thinnfeldia* and *Stenopteris*. Fragmentary reptilian remains occur in the sandstones. The largest portion I have yet found is the upper part of the humerus of a Dinosaur; the species to which it belongs has not been determined. The cast of a Cephalopodous shell was found by the writer in the Molteno Sandstones close to Morija, and I have heard of a similar discovery near Ficksburg. The Molteno Beds contain thin seams of coal, varying in thickness from 1 inch up to 6 inches. Usually the seams only extend a short distance and then break up into pockets. The coal is soft and of indifferent quality, but occasional seams of good quality are to be found, as for example at Mohale's Hoek, where a seam 6 inches thick exists of most excellent quality. It is worked to some extent by the natives. The plants composing the coal seem to have grown, generally speaking, in marshy depressions, as the presence of occasional trunks of trees in the sandstones indicates an old land-surface. I am aware that this is not the usual view held of the origin of the coal, but from observations at widely different places I have come to the conclusion that the drift origin of the coal-beds is not generally true. These seams of coal are widespread over the country, being found at places as far apart as 70 or 80 miles. The Basutos do not usually dig this coal. They try to conceal its whereabouts as much as possible, for fear of the white man seizing the country, and, with the example of other parts of South Africa before their eyes, one cannot wonder at their action.

About 50 feet above the horizon upon which the coal is found there is a bed of deep red conglomerate, containing pebbles of quartzite, evidently derived from Cape or pre-Cape rocks, varying in size from

a pea up to masses six or eight inches in diameter. The presence of these blocks must imply a considerable distance in transportation, as no rocks of this character occur nearer, I understand, than Pondoland, Griqualand West, or the Transvaal. As most of the ripple-marks in the sandstones indicate a current with an east to west direction, it is more likely they came from the first-mentioned place. This conglomerate is highly charged with ferruginous matter, so that its appearance is very characteristic. The thickness of the bed varies from three to five feet. This bed is usually taken as indicating coal beneath in Cape Colony, and I can confirm this from personal observation in Basutoland. It seems to be the higher of the two horizons upon which coal is found in the Molteno Beds. The lower is not exposed in Basutoland. The conglomerate is remarkably uniform and persistent all over the country, just a little above the plain, and in every exposure I have found indications of the presence of coal beneath. Good exposures of the Molteno Beds are difficult to obtain in Basutoland owing to the amount of detritus, which covers the slopes of the hills where they lie. This does not apply to the Red Beds and Cave Sandstone, splendid exposures of which occur everywhere.

Fossils,[1] except plants, are not plentiful, principally owing to the absence of good exposures, and also owing to the jealousy of the natives, which prevents any systematic search. Scattered bones occur, but I have seen no skulls or complete skeletons. The species to which these bones belong have not been determined. Large fossilised trunks of trees as much as 2 feet in diameter are not uncommon. These would indicate a land surface, at no great distance, or they may have been floated down by a river.

(3) The Red Beds lie conformably upon the Molteno Beds without any distinct line of separation, so that it is difficult to say where the one ends and the other begins. The name is an unfortunate one, and as the rocks are so characteristic and so persistent all over the country, the name could be very well changed in favour of some other designation. They are composed of red sandstones, blue, green, and chocolate-coloured mudstones and shales, the mudstones as a rule predominating. It is noteworthy that most of the green mudstones weather red, which gives the red portions of the beds an apparent thickness much greater than they really have. Ripple-marks and false bedding are extremely common, and nearly always indicate a current from an easterly and north-easterly direction. No plants have been found so far. Fossil wood is rather plentiful, and, of late, reptilian bones have been found in the Orange River Colony and North Basutoland in considerable numbers, indicating large and small Dinosaurs. The largest thigh-bone I have seen measures 19½ inches

[1] Since this was written footprints of reptiles have been discovered in Molteno Beds near the Tsuaieng River about 1½ hour's ride from Morija. They are four-toed and about 6 inches square, and belonged to some heavy-footed animal similar to a *Parœasaurus*, but certainly not this animal. They strongly resemble Labyrinthodont tracks. I am also informed by Mr. H. C. Sloley, Resident Commissioner of Maseru, that a skeleton of a Dinosaur of large size was found in the bed of the Tebetebeng River, and curiously enough was lying alongside of a doleritic dyke.

in circumference at the upper extremity of the shaft. Near the Caledon River outside of Ficksburg a large quantity of bones was recently found belonging to individuals of various sizes, and presumably of different species. The bones are broken and mixed up together as if they had been swept down into their present position by a flood. They are embedded in chocolate-coloured mudstone. So plentiful are they that a farmer has built the walls of his cattle kraal of blocks of stone containing fragments of bones.[1] In this band of mudstone are curious circular bombs of clay, filled with fine glassy sand, with a central nucleus of limestone, so that they look like howitzer shells. The diameter of these concretions is usually about 10 or 12 inches, and the thickness of the clay layers about 8 inches. The local name for them is "Basuto pots," and the term is certainly not inapplicable, as on breaking in the top the whole of the contents can be emptied out. Nodules are of frequent occurrence all through the Red Beds, and are more or less common through the whole of the Molteno Red Beds and Cave Sandstone. Silicified wood is fairly plentiful in the Red Beds, but the remains are mostly fragmentary; the largest portion of a tree I have seen measures 4 feet in length and 1 ft. 10 in. in diameter. It occurs between Cana and Hlotse. The Red Beds in many places must have been deposited in shoal water, as ripple-marked sandstone is very common, so much so in fact that the Rev. D. F. Ellenberger, of Masitisi, has built one of his outhouses and flagged all his floors with slabs of the most beautifully ripple-marked sandstone belonging to the upper members of the Red Beds. Fossil fishes have been found in the bed of the Telle River said to belong to the genus *Semionotus*, but I am not able to vouch for the accuracy of this. I understand these fish eventually found their way to the British Museum. Spines of a small carnivorous Dinosaur, *Massospondylus*, have also been found in the neighbourhood of Masitisi. The Red Beds are remarkably uniform in thickness and appearance all over the country. They have been traced for nearly 100 miles in practically a straight line without any marked difference, the average thickness being about 300 feet. In some places in South Basutoland they are 400 feet thick. They lie nearly horizontally on the Molteno Beds, partaking of their general easterly dip.

(2) The Cave Sandstone is extremely difficult to separate from the underlying Red Beds, which pass up into it without any marked difference. Thus there is no definite line of demarcation; Red Beds occur in what I consider Lower Cave Sandstone, but the Cave Sandstone is distinguished, especially in its upper members, by its greater massiveness, and also by its prevailing grey colour. It forms precipices round the tops of the hills, in many cases overhanging. The individual beds are very thick, and the rock does not readily split into laminæ. The Cave Sandstone weathers into huge pillars, or breaks off in immense blocks hundreds of tons in weight. These

[1] The Rev. H. Digterlen, of Leribe, has a vertebra of a Dinosaur, 6 inches in length, which is said to have come from Red Beds, and also near his station there is a portion of an arm-bone, embedded in grey mudstone, just at the base of the Red Beds.

strew the hill-sides everywhere, so that one can always tell when one is in the neighbourhood of this rock by the character of the fallen blocks on a slope. A good example of the pillar formation is to be seen at the station of Thaba Bosin. A small hill named Qiloane, evidently at one time connected with Thaba Bosin mountain, but now separated by a valley a mile wide and over 600 feet deep, is crowned by a pillar of Cave Sandstone some 100 feet high. It is about 15 feet broad on top, and is composed of three immense steps gradually tapering to a point. The precipices of the Cave Sandstone are usually covered with a blackish glaze, the effects of sun and rain, which renders them very slippery. The rock is perforated with openings, especially near the crests of the hills, but though these openings have given the rock its present name they are not true caves, being usually due to the more rapid erosion of the bands of blue clay with which the rock is interstratified, especially in its lower members. They are merely shelters with overhanging ledges. Instances of true caves do occur, but they are uncommon. The Bushmen inhabited these caves in former times, and also cannibals—the remnants of tribes broken up by Chaka and Umsilikazi in their sanguinary raids and driven to cannibalism by fear and starvation.[1] One very large cave near the station of Cana is still called the Cannibals' Cave, and the people point out the ledge upon which the cannibals slaughtered their victims, appealing to the blood-stains on it in proof of their assertion. Needless to say, the ledge is nothing more than green mudstone, which has weathered red. The Bushmen have left traces of their occupation of the country in the paintings on the walls of these rock shelters. Many of these paintings are remarkable for their finish and accuracy of delineation. One of the largest series of paintings is to be found two hours from the station of Thaba Bosin. On the rock face are hundreds of paintings of elands, some of them 24 inches long and 9 inches high, hartebeest, 'gnu, storks, and jackals, all in the natural colours of the animals. The bodies of the elands are painted brown, while the neck, head, and belly are white. Mixed with these are scores of men in rows with bows and arrows, evidently fighting. At one place a Bushman is stealing up to a hartebeest grazing in rather long grass, with his arrow on the string. At another place we can see the hunter charged and knocked over by the infuriated animal he has just shot. On another part of the rock lions are depicted in their tawny colour, some leaping upon game, others on the *qui vive*. Then there are jackals and curious drawings representing snakes or perhaps mythological signs. Unfortunately most of the paintings have been spoiled by the fires made by the Basuto herd boys. The Basuto see no beauty in and put no value upon these paintings, and their wanton destruction is very often encouraged by the chiefs themselves, in order to prevent Europeans from visiting the country. Other beautiful sets of paintings occur at Schonghong on the Upper Orange River, the finest set in the country, at Hermon, Thabana, Morena, Masitisi, Kolo, Qeme, Teyateyaneng, Qalo, and many other places. Those at Masitisi are remarkably good, but the figures are small. They are

[1] Voyage d'exploration, par M. Arbousset, 1853.

comparatively recent, certainly within 70 years or so, as horses and riders are depicted upon them, and these animals were not brought into Basutoland till the early part of last century.

Fossils are comparatively rare in the Cave Sandstone, but although the actual remains of the animals are seldom met with their footprints are fairly common. The remains of the forearm and part of the shoulders of a Dinosaur, species undetermined, occur at Sebapala.[1] The footprints of Dinosaurs of large size occur at the following places, all in a band of green mud about 18 inches thick, viz., Tsikuane, Qalo, Morija, and Teyateyaneng. Those at Qalo are most distinct, showing the corrugations of the skin. The largest prints are 14½ inches long by 10 wide. Other impressions are shown in relief on the roof near by. The animals walked from west to east up-stream, over the bed of a river, as indicated by the ripple-marks, similar to what one sees every day in the beds of all the large rivers. This green mudstone is interesting as it lies on a jagged surface of coarse sandstone, and points to some denudation having previously taken place.

At Tsikuane, 25 miles further south-west, a magnificent series of dinosaurian footprints are to be seen in the same green mud, on the underside of an overhanging cliff. They are all in relief. The huge block which has broken off, with the impressions in their natural state, lies below. There are more than 50 of these prints all with the same general direction from west to east, but crossing and recrossing each other in the most extraordinary fashion. Large and small are mixed up together, but the great bulk of them are small prints. There are two sets of very large prints most conspicuous, evidently belonging to two large individuals. The length of these tracks is not less than 15 inches (middle toe). They are all of the three-toed variety. A study of these footprints, which ramble about a great deal, shows that they were probably not all made at one time, as some have been imprinted on the others subsequently, when they had to some extent hardened, for if they had all been formed at the same time the first would have obliterated the second. One is irresistibly driven to the conclusion that these prints belong to a single family of Dinosaurs. This would imply that Dinosaurs were rather prolific, or that their families remained with them a long time. Another and more probable suggestion is that the animals were gregarious.[2]

At Morija, 75 miles further south-west, there are two slabs containing dinosaurian tracks. The smaller contains one large and a few small impressions. The larger slab is many tons in weight, and in falling has split into two, showing the tracks in reverse. It contains three different sets of impressions large and small, belonging to individuals of different sizes and possibly of different species. Here the same crossing of prints occurs as at Tsikuane. The middle toe of the largest track is 15 inches long, and the stride 3 ft. 3 ins. to 5 feet. Besides these impressions it contains well-preserved sun-cracks, showing

[1] Part of a jaw was found near Morija: it probably belongs to *Hortalotarsus*.

[2] Since writing this, further study of these footprints has convinced me that what I took to be footprints partially obliterated by others made long subsequently were only the partial obliteration made by the hind-feet of animals following the others immediately.

that the animals walked over the muddy flats of a lake or river before they were dry. These tracks occur in the same band of green mud as at Tsikuane and Qalo, with ripple-marks and sun-cracks, just what one sees on the muddy bottoms of many of the large rivers to-day.

(*To be concluded in the March Number.*)

III.—A Revision of some Carboniferous Corals.[1]

By R. G. Carruthers, of the Geological Survey.

(PLATES IV AND V.)

(*Continued from the January Number, page* 31.)

Zaphrentis delanouei, M.-Ed. & H. (Plate V, Figs. 5–7.)

1851.	*Zaphrentis delanouei*,	M.-Edwards & Haime:	Pol. Foss. d. Terr. Pal., p. 332, pl. v, figs. 2–2*c* (*syn. exclusa*).
1860.	,,	,,	M.-Edwards: Hist. nat. d. Corall., t. iii, p. 339.
1861.	,,	,,	de Fromentel: Int. à l'Et. polyp. foss., p. 288.
1869.	,,	,,	Kunth: Zeit. d. deut. Geol. Gesell., vol. xxi, p. 665, pl. xviii, fig. 6.
1872.	,,	,,	de Koninck: Nouv. Recher. sur. Anim. Foss. d. Terr. Carb. d. l. Belg., p. 101, pl. x, figs. 6, 6*a*.
	,,	*Clifford*[illegible]*na*?	ibid., p. 105, pl. x, figs. 9, 9*a*.
1905.	,,	aff. *phillipsi* (pars),	Vaughan: Q.J.G.S., vol. lxi, pl. xxii, figs. 2, 2*a*.

External Characters.

Corallum conical and, as a rule, gently curved, though often straight; a short broad outline is not uncommon.[2] The *epitheca* has well-marked longitudinal ribbing, sometimes obscured by fine annular striations in the neighbourhood of the calyx; slight constrictions of growth may occur, but there is never an interruption in the continuity of the epitheca. Good figures are given both by Milne-Edwards & Haime and by de Koninck.

Calyx deep, with a thin rim and steep sides. The *major septa* are strong, well separated, and very regularly arranged, with a characteristic curvature convex to the fossula. This curvature is not so apparent in adult calices (Pl. V, Fig. 5*a*); it is best seen in young specimens, where also the septa in the two cardinal quadrants are arranged as if overlapping those in the counter quadrants (see de Koninck's figure of *Z. Cliffordana*, Pl. x, fig. 9*a*, Nouv. Recher.). The inner ends of the major septa are, as a rule, slightly thickened,

[1] Communicated by permission of the Director of the Geological Survey of Great Britain.

[2] In a few rare cases the coral may become cylindrical in the final growth stages and the septa then become amplexoid, retreating from the upper surface of successive tabulæ. The commencement of such a stage is indicated in Pl. V, Fig. 6. A unique specimen from Tournai, now in the Survey collection (R.C. 330), shows this habit. It is 4·5 cm. in length, and the cylindrical distal portion measures 2·5 by 1·3 cm. No trace of marginal dissepiments appears, either in the longitudinal section or in the calyx. In other species amplexoid septa accompany the acquisition of a cylindrical habit, and fuller reference to the matter will subsequently be given under *Caninia cornucopiæ*, Mich.

and are intimately fused together. They do not quite reach the centre of the calicinal floor, where there is consequently a small tabular area about 2 mm. in diameter, forming the inner end of the fossula. This small tabula is, however, not often found preserved, and in that case the centre of the calyx presents a smooth-walled tubular space (see Pl. V, Figs. 5, 5*a*).

The *minor septa* are entirely rudimentary. They are seen around the interior of the calyx as low ridges between the thickened bases of the major septa; those on either side of the counter septum are sometimes longer than the others.

The (cardinal) *fossula*, unlike that of most rugose corals, lies on the concave side of the corallum;[1] it is always very distinct, extending to the centre of the calyx, and, especially in young specimens, often beyond. The outline is continuous and even, becoming sometimes slightly narrower midway in its length, and having a marked expansion at the inner end (Pl. V, Fig. 5*a*); although so smooth, the bounding walls are purely septal, and there does not seem to be any accessory thickening, as in *Z. koninecki*. Good figures of the calyx are given both by Milne-Edwards & Haime and by de Koninck, although in that of the latter the perspective is somewhat faulty. Both figure specimens in which the central tabular area is preserved, so that the fossula appears much narrower and shorter than it does in Pl. V, Fig. 5*a* (where the tabular area has been destroyed), or than it does in transverse sections.

Average dimensions.

Height of an adult specimen, 2·5 cm.; diameter of calicinal rim, 1·3 cm.; number of major septa with above diameter of calyx, 27; depth of calyx, 1 cm.

INTERNAL CHARACTERS.

(a) *Transverse Sections.*—The mode of septal arrangement does not differ greatly from that seen in the calyx, though the curvature of the septa convex to the fossula is more clearly shown. In the lower part of the coral it is common to find the fossula relatively wider and larger in every way than in the upper sections, and expanding continuously from the wall to the centre of the coral (Pl. V, Figs. 6*b* and 7). The cardinal septum is long and thin, completely dividing the fossula till just below the calyx, where it rapidly dwindles in length. There is never any indication of a counter fossula, nor is the counter septum of itself in any way differentiated from its neighbours.

The *minor septa* are extremely rudimentary. They may be barely perceptible, even in calicinal sections of a mature individual, but occasionally those on each side of the counter septum are more prominent than the rest, affording useful evidence in the identification of that septum.

(b) *Vertical Sections.*—The simple tabulæ, arched in the centre, from 1 to 2 mm. apart, and with a strong depression at the fossula, call for no special remark. A text-figure (Diagram C) is given to illustrate their nature.

[1] It is, however, sometimes laterally disposed, and in one or two rare instances lies distinctly on the convex side of curvature.

Localities.

Visean: Ashfell Beds (S). Thorlieshope and other quarries in the Cement Stone Series of Liddelsdale.[1]

Tournaisian: Z_1 subzone and horizon β: Avon Gorge, Walton Castle (Clevedon), Abbotsleigh, and Burrington (especially at Goatchurch Cave).

Remarks.

The enlarged figures on Pl. x of de Koninck's "Nouvelles Recherches" of a coral doubtfully ascribed by the Belgian author to *Z. Cliffordana*, M.-Ed. & H., represents a young example of *Z. delanouei*. Such was apparent on an inspection of the figured specimen; two similar ones are represented in the Piret Collection. These, on slicing, afforded sections identical with those cut near the tip of a typical example of the species.

Diagram C.—*Zaphrentis delanouei*, M.-Ed. & H. Cement Stones, Liddelsdale. M. 289*f*. Geol. Surv. Scot. Vertical section in a plane at right angles to the cardinal fossula, showing the tabulæ; the shaded parts represent intersections of septa in the plane of section. ×2.

Z. delanouei is a well-marked species. Though often identical with *Z. omaliusi* in size, shape, and epithecal characters, marked differences of septal arrangement are displayed in the calyx and in transverse sections. The curvature of the septa convex, instead of concave, to the cardinal fossula, the large size, the extent, and position relative to the curvature of the corallum, of the cardinal fossula, and the entire absence, at any period of growth, of a counter fossula, are all characters which at once distinguish *Z. delanouei* from *Z. omaliusi*. When any doubt occurs, a section in the lower part of the coral should dispose of the difficulty, since it is here that the septal grouping in these two species is most characteristically shown.

The only other Tournaisian coral with which, so far as I am aware, the species could be confused, is perhaps *Caninia cornucopiæ*, Mich. M. de Koninck noticed that there is a resemblance in the calyx of these two corals. The differences (which are very apparent in transverse sections) will be dealt with in the description of the latter species.

Certain Visean Zaphrentids show considerable resemblance to *Z. delanouei*, though, as will be noticed later, the species itself does not seem to occur in that division of the Carboniferous Limestone, or at any rate, only in the lower part. Of these, a mutation, as yet undescribed, though extremely abundant in the Carboniferous Limestone Series of Scotland, only differs in the constricted shape of the fossula, which

[1] Ranging probably from the Upper Tournaisian to the Lower Visean.

narrows rapidly from the outer to the inner end instead of expanding, and in the shortening of the cardinal septum very early in the growth of the coral. Intermediate forms also exist, where the sides of the fossula are parallel from end to end. These mutational forms will be dealt with in a future paper on the evolution of the species. Meanwhile, in my opinion, the name *Z. delanouei* should be restricted to those corals where the fossula, in a section cut just below the calyx, is clearly more expanded at its inner than its outer end, and where, of course, the other characters of the species are present. Another somewhat similar Visean Zaphrentid is *Z. enniskilleni*. This may be distinguished from *Z. delanouei* by its larger size, a more irregular outline of the fossula, and by an absence of the thickening and intimate fusion of the inner ends of the major septa, so well seen in the latter species, while the septa are more irregular in their disposition, and are often discontinuous.

It has, unfortunately, not been possible to obtain serial sections of this beautiful species, suitable for reproduction, in an unbroken condition, at any rate so far as fully grown forms are concerned; the large fossula and simple tabulæ make the coral peculiarly liable to fracture. The partially restored sections on Pl. V, however, represent the average of a considerable number of specimens, and it is hoped that they will serve as accurate delineations of the mature coral.

Distribution.

Dr. Vaughan has kindly contributed some notes on the distribution of *Z. omaliusi* and *Z. delanouei* in the South-Western Province. After referring to the separation of *Z.* aff. *phillipsi* into these two species,[1] he says:—

"Being convinced of the justification for this separation, I have assiduously collected[2] from the *Zaphrentis*-zone in the Bristol, N. Mendip and Weston areas, with the view of determining the distribution of these two species. The results of this revision are highly satisfactory in their definiteness, viz.:—*Z. delanouei* is practically confined to Z_1, being only doubtfully recorded from Z_2 of Portishead. It is prolific at the base (Horizon β), but rare in Upper Z_2: *Z. omaliusi* teems in Z_2 and at several levels in the lower part of C. It is practically unknown from Z_1, being very doubtfully recorded from β of Burrington. In the Gower the resolution of *Z.* aff. *phillipsi* into its component species has yet to be studied, but the results of such revision will, however, in no way affect the zonal sub-divisions established in the [Bristol] paper from the consideration of broad faunal assemblages, in terms of which the distribution of the components will have to be expressed. Since the distribution and structural characters of the *Zaphrentes* and *Campophylla* in County Dublin have an important bearing upon the correlation of the beds, and since the Densiphyllid Zaphrentes are practically unknown except as rare

[1] As Dr. Vaughan informs me, the description of *Z.* aff. *phillipsi* in his original paper (Q.J.G.S., vol. lxi, p. 270) is only applicable in its entirety to *Z. omaliusi*.

[2] "In this work I have received very valuable assistance from Mr. W. H. Wickes, Professor S. H. Reynolds, and Mr. H. F. Barke; Mr. Carruthers has uncomplainingly checked the identification of almost every specimen."

unstable sports in the South-Western Province, a discussion of the Irish material must be deferred, and will accompany Dr. Matley's forthcoming account of the Rush to Skerries section."[1]

The range of *Z. delanouei* seems more extensive in Scotland than in the South-Western Province. A large number of specimens have recently rewarded the diligent search of Mr. A. Macconochie; these were found at several horizons in the Cement Stones of Liddelsdale, up to the base of the Fells Sandstone. The great majority were dwarfed forms, in common with the associated fossils; conditions in these deposits seem to have been quite unfavourable to a free development of marine life. The species also seems to occur at a somewhat high level in the North of England. Some small corals in Professor Garwood's collection from the Ashfell Beds, provisionally correlated by him with the lower Visean level S_1–S_2, seem clearly referable to *Z. delanouei*; it is noteworthy that one or two associated forms are intermediate in type between *Z. delanouei* and the characteristic Visean coral *Z. enniskilleni*.

Zaphrentis koninckı, M.-Ed. & H. (Plate V, Figs. 1–4.)

1851.	*Zaphrentis koninckı*,	M.-Edwards & Haime: Pol. Foss. d. Terr. Pal., p. 331, pl. v, figs. 5, 5*a*.
—	,,	*cornucopiæ*, ibid., p. 331, pl. v, figs. 4, 4*a*.
—	,,	,, Bronn u. F. Roemer: Lethæa geogn., Th. ii, p. 192, pl. vi, fig. 17.
1852.	,,	,, M.-Edwards & Haime: Brit. Foss. Cor. (Pal. Soc.), p. 167.
1860.	,,	,, M.-Edwards: Hist. nat. d. Corall., t. iii, p. 338.
1861.	,,	,, de Fromentel: Int. à l'et. polyp. foss., p. 287.
—	,,	*koninckı*, ibid., p. 287.
1872.	,,	,, de Koninck: Nouv. Recher. sur. Anim. Foss. d. Terr. Carb. d. Belg., p. 98, pl. x, figs. 3, 3*a*.
—	,,	*intermedia*, ibid., p. 99, pl. x, figs. 4, 4*a*.
—	,,	*le Honiana*, ibid., p. 106, pl. x, figs. 10, 10*a*.
1905.	,,	aff. *cornucopiæ*, Vaughan: Q.J.G.S., vol. lxi, p. 271, pl. xxii, figs. 3–3*d*.

External Characters.

Corallum conical, slender, and gently curved. The *epitheca* is smooth without longitudinal ribbing, but usually with annular striations and constrictions of growth, while an interruption of the continuity of the epitheca through rejuvenescence is by no means uncommon (see outline of Fig. 2, Pl. V). Good figures of small specimens are given both by Milne-Edwards & Haime and by de Koninck.

Calyx of moderate depth, bell-shaped in vertical section, with closely-packed septa.

The *major septa* are usually thin, always thickened at their outer ends and usually also at their inner ends, which are fused together in the centre of the coral. This may give rise to more or less elevation in the centre of the calicinal floor; but since the inner ends of the counter septum and its neighbours are often not so affected, this

[1] This refers to the recent discovery of *Z. delanouei* and Densiphyllid Zaphrentids in conjunction at Malahide, co. Dublin.

elevation may disappear at that point of the calyx, while in many examples of this species it is not present at all. The feature is commonest in the calices of young specimens.

The (cardinal) *fossula*, lying on the convex side of the corallum, is very deep and distinct, extending to, or beyond, the centre of the calicinal floor, and with a characteristically smooth, even outline, due to the presence of a distinct and continuous stereoplasmic lining; as a rule the fossula is long and narrow, with an expansion at the inner end of varying degree (Pl. V, Fig. 4*a*); it may, however, be widely expanded internally, especially in young specimens.

The *minor septa* are almost always well developed, although at first sight this would not seem to be the case, since they are fused with the major septa for the greater part of their length, and so give rise to a broad and more or less solid rim inside the top of the calyx, beyond which they project but slightly (Pl. V, Fig. 4*a*). They taper to a thin point in the interseptal chambers.

Milne-Edwards & Haime and de Koninck both give good figures of the calyx, but the perspective does not express the peculiar bell-shaped cup very well.

Average dimensions.

Height of an adult specimen, 2·5 cm.; diameter of calicinal rim, 1·3 cm.; depth of calyx, ·8 cm.

Internal Characters.

Transverse Sections.—The *major septa* show similar characters to those seen in the calyx. They are more or less straight, while the thickening at their outer and inner ends is well shown, being generally rather more apparent in the two cardinal quadrants (Pl. V, Fig. 3). As a rule those septa at the counter end of the section show less thickening at their inner ends, and often become subparallel, especially in sections across the younger parts of a corallum.

The (cardinal) *fossula* shows great variation in shape, but is always very prominent. As a rule in the young parts of a corallum it is more expanded than in the mature portions (Pl. V, Figs. 1*a* and 3*a*–3*c*); but the open portion may be very small if the stereoplasmic lining is greatly developed (Pl. V, Figs. 1*a* and 3*c*). The fusion of the inner ends of the major septa with this lining is very complete.

The cardinal septum only extends down the middle of the fossula to the centre of the section in the very young stages of growth. It rapidly shortens higher up the corallum, so that in sections across the more adult portions it is similar in size and shape to the minor septa. These latter are usually well developed,[1] and being fused with the sides of the major septa to a great extent, give the appearance of a very thick wall to the coral (Pl. V, Fig. 1, etc.). The thin pointed ends are sometimes joined with a major septum. They appear very early in the life of the coral, and are seen even in the young stages of growth.

[1] I would regard the minor septa seen in Pl. V, Fig. 1, as having the greatest length attained in *Z. koninckii*, as here defined.

Vertical Sections.—The *tabulæ* are numerous, decidedly irregular and vesicular in character, and are strongly arched in the centre of the coral, with a well-marked depression at the fossula (Pl. V, Fig. 2). Vertical sections cut clear of the fossula show a similar arrangement of the tabulæ to that seen in fossular sections, although the strong upward bending in the middle of the coral is naturally not so apparent. There are no dissepiments.

Localities.

Visean (C_2–S): Hazelback (Caninia bed) and Arnside, apparently rare at both localities.

Tournaisian (Z_2 & Y): many localities in the Bristol district (see Dr. Vaughan's paper, Q.J.G.S. 1905), but especially at Big Weston Wood Quarry, Portishead (Z_2), Cromhall (Z_2 & Y), and Strawberry Hill, E. Clevedon (Z_2).

The material at hand was not sufficient to adequately examine the variation of this species, though the facts ascertained may not be without interest.

As regards shape, a definite division into three main groups seems justifiable. These are sufficiently distinct to warrant separation, although they do not merit varietal rank, for the septal characters and arrangement in all three divisions are identical. They may conveniently be referred to as (1) *forma typica*, (2) *forma α*, and (3) *forma β* (see Diagram D).

Diagram D.—Outlines of *Z. koninckii*, M.-Ed. & H. All half natural size. 1, forma typica; 2, forma α; 3, forma β.

The first group (*forma typica*) exemplified in those specimens on which the species were founded, is well represented in the Piret Collection, and seems the common form at Tournai (an example is given in Pl. V, Fig. 4), and may also be seen in specimens from the Upper Tournaisian of the Bristol district, and from the lower Visean at Arnside; the second group (*forma α*) is, as Dr. Vaughan has noticed, the dominant form in the Bristol district,[1] while the third group (*forma β*) is found chiefly at Cromhall, near Bristol, and at Arnside also. These growth forms do not seem to be of evolutionary value, and may perhaps be due to environment.

As regards internal structure, some curious features are displayed in a specimen from Tournai, in the Piret Collection (R. 11,677). Externally, this specimen is of large size, with abundant strongly marked constrictions of growth, giving a very corrugated aspect to the coral. When sliced in serial transverse sections, it was apparent that

[1] Dr. Vaughan has figured an example in his Bristol paper (Q.J.G.S., vol. lxi, pl. xxii, fig. 3).

in the upper portion of the coral the septa are impersistent, many of them only reaching the centre of the coral as lines on the surface of the tabulæ; consequently there is a bare tabular area of considerable size in the centre of some of the upper sections, while in the calyx itself the bare tabular floor amounts to two-thirds the diameter of the coral.

A few fragments of a similar form have been found by Dr. Vaughan at Cromhall, in association with more normal examples of the species, including some of large size, but the evidence at present forthcoming does not warrant the establishment of a distinct variety.

A mutation of *Z. koninckí* has been briefly described by Mr. Sibly.[1] The chief difference from the normal species appears to lie in the large size of the coral and the more elongated minor septa. Similar forms have been collected by Professor Garwood from Arnside (where the normal species seems rare) together with a further mutation, noticed by Dr. Vaughan, who has kindly supplied the following notes on the form[2]:—

"*Z. koninckí*, mut. C_2.—This mutation exhibits a marked convergence with *Cyathophyllum* φ, the dominant coral of the C_2 beds. The form is continuously conical and cornute, and the dimensions are large compared with those of typical representatives of the species (the average length is nearly 9 cm.). The septal plan is essentially that of *Z. koninckí*, but differs in the conspicuous elongation and distinctness of the secondary [minor] septa. All the septa are attached to the wall by short thickened bases, and the fossula has the elongated parallel-sided section of that in most forms of *Z. koninckí*. The striking resemblance to *Cyathophyllum* φ is caused by: (1) the external zone radiated by primaries and secondaries" [major and minor septa]; "(2) the apparent development of vesicles in the internal area (as seen in horizontal sections); (3) the type of fossula. The differences are: (1) the apparent absence of vesicles in the external area; (2) the attachment of the septa to the wall by markedly thickened bases."

Remarks.

MM. Milne-Edwards & Haime, in establishing the above species, notice its similarity to the coral erroneously ascribed by them to Michelin's *Caninia cornucopiæ*. In separating the two, they notice that *Z. koninckí* has (1) a circular instead of an oval calyx; (2) thirty instead of thirty-two septa, which are (3) thicker at their outer ends and form a prominent lobe near the septal fossula; (4) a fossula more enlarged in the middle and not extending so far across the calyx, and finally (5) 'altogether rudimentary' minor septa.

M. de Koninck's description (Nouvelles Recherches, etc., p. 99) also agrees with theirs, but after showing that the French authors were mistaken in their diagnosis of *Caninia cornucopiæ* he gives a new name, *Zaphrentis intermedia*, to the coral they considered referable to Michelin's species.

[1] F. Sibly, "Carboniferous Limestone of the Mendip Area": Q.J.G.S., vol. lxii (1906), p. 366.

[2] In these notes it should be understood that *Z. koninckí* is equivalent to *Z.* aff. *cornucopiæ* of Dr. Vaughan's earlier papers.

The differences between *Z. koninckı* and *Z. intermedia* above noted, appear at first sight quite sufficient to justify the relegation of the two corals to different species. But a close examination of several well-preserved examples of these corals from Tournai, and especially of serial transverse sections from them, in my opinion show that the two are essentially identical. The differences are, in the main, a matter of preservation and form of growth. The first two points, i.e., the shape of the calyx and the number of septa, are not of value unless dimensions are given, since they depend on the age and growth of the coral. MM. Edwards & Haime do not give the dimensions of *Z. koninckı*; according to M. de Koninck they are about the same as those of *Z. intermedia*; a very slight difference in size would account for the septa being a little different in number.

The last three points, concerning the character of the septa and the fossula, are, however, of greater importance. Serial transverse sections show them to depend to a great extent on the amount of stereoplasmic thickening present. If this is considerable, the lobing of the major septa at their inner and outer ends is emphasized, causing a close fusion of the outer ends with the inner septa; the latter consequently project very slightly into the interseptal chambers, and so have a rudimentary appearance in the calyx, but in the absence of thickening seem long and prominent. At the same time the fusion of the inner ends of the major septa with themselves and with the fossular lining becomes more intimate than usual; this, in the calyx (and it was on the aspect of the calyx that the species were founded) gives rise to more or less elevation in the centre of the calicinal floor, which is otherwise flat. The most striking difference, however, between the figured specimens of these two 'species,' lies in the shape of the fossula. But this, in serial transverse sections of specimens similar to those figured by de Koninck, is seen to vary to a remarkable degree during the growth of the coral, and, further, like the septa, to be affected by the presence or absence of accessory thickening. This is very well exhibited in a typical example of one of these corals from Tournai, part of which is here figured (Pl. V, Figs. 3–3*c*). An examination of these transverse sections shows that in its young stages there is a widely expanded fossula, largely filled up by a stereoplasmic deposit (Pl. V, Figs. 3*a*–3*c*). In successively higher sections this lessens, the fossula then becomes constricted (Pl. V, Fig. 3), while in the last section (not figured) it expands again internally, but finally in the calyx again assumes a constricted and elongated form. These sections show further that the thickening of the inner ends of the major septa is quite as variable at various points of the coral's growth.

These facts clearly show that if the calyx of this particular example could have been examined at various periods of growth, the coral would be referred at one time to *Z. koninckı*, at another to *Z. intermedia*.

Precisely similar appearances were afforded by similar serial sections of a large number of these corals collected by Dr. Vaughan in the Bristol district. It was found impossible to draw any valid distinction between *Z. intermedia* and *Z. koninckı*; the latter name having considerable priority has therefore been retained.

No doubt examples can be found that have the characters of one of these so-called species throughout its growth. In particular, I have noticed a few small specimens (e.g., R. 11,676) which possess a short enlarged fossula throughout and short minor septa, corresponding to *Z. koninecki* as originially defined. But the great majority of these corals which I have examined, are in accordance with the description and figures accompanying the present paper.

It is not surprising that the French and Belgian authors employed two names for this coral. Such a course was indeed a perfectly natural one, since their observations were of necessity confined to the calyx; in such circumstances it was impossible for them to be certain that they were concerned with a single species.

One other point in connection with the synonymy of this species remains to be considered. *Zaph. le Honiana*, de Kon., was a species founded on a single specimen; according to the author, it differed from *Z. koninecki* in the greater development of the septa, and in the less elongated shape of the fossula, and from *Z. intermedia* in the number and length of the septa.

An inspection of the type-specimen showed that it was in reality an unusually large example of *Z. koninecki*. This accounted for the number of the septa (40 instead of 32, the diameter of the calyx being 1·5 cm. instead of the 1 cm. of the ordinary *Z. koninecki*). The shape of the fossula and the development of the septa (i.e., their prominence in the calyx) we have seen to be unreliable in these corals. Although the central portion of the calicinal floor is broken away in the type (the interior was destroyed during silicification and is now quite hollow), nevertheless the nature and arrangement of the septa around the calyx are clearly seen to be identical with those in *Z. koninecki*, as here defined, and to the latter species, in my opinion, the coral must undoubtedly be referred.

One small point concerning the figure of the calyx of *Z. le Honiana* (Nouv. Recher., Pl. x, fig. 10*a*) may be mentioned. The epitheca in that figure seems unusually thick. In reality it is of medium thickness, and the appearance is due to a constriction of growth having taken place at the very top of the calyx.

Distribution.

Z. koninecki appears to have a distinct zonal value, although it must be confessed that our knowledge of its distribution outside the South-Western Province is as yet very scanty, since the only district outside that region from which the species has been reported is that of Arnside in the North of England. Concerning the occurrence of the species in the South-Western Province, Dr. Vaughan has supplied the following notes, while he has also added a few words on the Arnside specimens:—

"As I have already pointed out in the Bristol paper, our form is conspicuously elongate when compared with the figure of *Z. cornucopiæ* given by Edwards & Haime (referred above to *Z. koninecki*). The recent revision of the Z fauna has added nothing to our previous knowledge of the range of this species; its entrance may be conveniently taken as marking the base of Z_2, its maximum

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4a

4b

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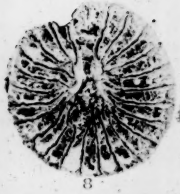
5a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7

7a

7b

Figs. 1-4.—*Zaphrentis amalius*, Edw. & H.; and Figs. 5 to 8. Varieties.

CARBONIFEROUS LIMESTONE.

occurs immediately below γ, and it diminishes in numbers in C_1. In the Gower the typical species is not uncommon at Threecliff Bay (the base of C_2), but in Upper C_2 it is replaced by the C_2 mutation (for description see notes on the species previously given). From Arnside (Lakesland) in beds which he correlates with C_2–S, of the South-Western Province, Professor E. T. Garwood cites *Z. cornucopiæ*[1]; the specimens belong to this mutation, and are apparently not uncommon."

Professor Garwood has kindly allowed me to examine his material; while most of the specimens clearly belong to the C_2 mutation above referred to by Dr. Vaughan, one specimen (Arnside) with minor septa of moderate length, I would refer to *Z. koninecki* as here defined, as also a further specimen from the *Cuniña* bed at Hazelback. The Arnside specimen, in outline, agreed with *Z. koninecki*, forma β, as opposed to the forma *a* commonly found in the Bristol district, but was otherwise similar to the specimens figured on Pl. V. The shape of the Hazelback example could not be ascertained as it was embedded in the limestone. The section agreed very closely with that on Pl. V, Fig. 1.

Some further specimens collected from Arnside by Dr. Wheelton Hind and forwarded to me by Dr. Vaughan, also yielded a good example of *Z. koninecki*, forma typica, but the remainder belonged to the C_2 mutation.

Summarising the evidence, therefore, it seems that in the Bristol district *Z. koninecki* characterises the uppermost Tournaisian beds, while in the Gower it occurs at a somewhat higher level, in the lower Visean, and in the North of England, at Arnside, probably on a still higher horizon, but at both of these last localities a mutational form becomes predominant.

EXPLANATION OF PLATES.

Plate IV.

The register numbers refer to specimens in the British Museum (Natural History) unless otherwise stated.

Zaphrentis omaliusi, M.-Ed. & H.

Figs. 1–1*a*.—Transverse sections from a typical individual, that in Fig. 1 cut just below the calyx floor. Indications of a counter-fossula are shown. × 3. Tournaisian (Z_2 subzone): Wood-spring, near Bristol. Vaughan Collection.

Fig. 2.—Profile of a young example. × 3. Tournai. R. 11,658.

Fig. 3.—Another transverse section, cut just below the calyx floor. × 3. Waulsort. Mus. Roy. d'Hist. Nat. Brussels.

Figs. 4–4*b*.—Serial transverse sections of another example. × 3. The calyx agrees well with those figured by MM. Milne-Edwards & Haime and de Koninck. Tournai. R. 11,675. (Camera lucida drawings.)

Var. ambigua, var. nov.

Figs. 5–5*a*.—Transverse sections from a typical example. × 3. Upper (?) Visean: Horrocksford Quarry, near Clitheroe.

Fig. 6.—Transverse section just below the calyx of an unusually large specimen, lower sections of which agree with those in Figs. 5–5*a*. × 3. Tournaisian (Z zone); coast at Rush, co. Dublin. Matley Collection.

[1] Geol. Mag., 1907, p. 73.

Var. DENSA, var. nov.

FIGS. 7–7*b*.—Serial transverse sections (type-specimen). × 3. The septa in the highest section (Fig. 7) were partly silicified, and a camera lucida drawing was necessary to show their disposition clearly. Tournaisian: coast at Malahide (locality 1), co. Dublin. Vaughan Collection.

FIG. 8.—Transverse section of another example. × 3. The section is cut just above the floor of the calyx; the cardinal septum is therefore very short and some of the septa disconnected. Tournaisian (Z_2 subzone): Big Weston Wood Quarry, Portishead, near Bristol. Vaughan Collection.

PLATE V.

The register numbers refer to specimens in the British Museum (Natural History).

ZAPHRENTIS KONINCKI, M.-Ed. & H.

FIG. 1.—Transverse section of a mature individual, cut just below the floor of the calyx. × 3. Tournaisian (Z_2 subzone): Strawberry Hill, East Clevedon, near Bristol. Vaughan Collection.

FIG. 1*a*.—A further section cut 1·3 cm. below preceding. × 3.

FIG. 2.—Vertical section cut down the cardinal fossula. Nat. size. The thick black line represents the wall, and the shaded parts the intersections of septa in the plane of section. The vesicular tabulæ, depressed in the fossula (to right-hand side of figure), are shown, and also the interruption in the epitheca through rejuvenescence. The calyx of this specimen was identical with that shown in Fig. 4*a*. Tournai. R. 11,678. Camera lucida drawing.

FIGS. 3–3*c*.—Serial transverse sections of a typical example. × 3. Parts of the wall have been destroyed by silicification, as also some of the tips of the minor septa. Tournai. R. 11,661. Camera lucida drawings.

FIG. 4.—Profile (*forma typica*). × $\frac{3}{2}$. Tournai. R. 11,660.

FIG. 4*a*.—Calyx of preceding.

ZAPHRENTIS DELANOUEI, M.-Ed. & H.

FIG. 5.—Front view of a typical example. Half of the calicinal wall is broken away, displaying the septal arrangements within. The central tabular area is destroyed. × $\frac{3}{2}$. Tournai. R. 11,682.

FIG. 5*a*.—The same, seen from above.

FIGS. 6–6*b*.—Serial transverse sections from a mature individual. Camera lucida drawings: the parts without detail are restored. × 3. Tournaisian (horizon β): Avon Gorge, Bristol. Vaughan Collection.

FIG. 7.—Transverse section of a young individual. × 3. Tournaisian: coast at Malahide, co. Dublin (locality 1). Vaughan Collection.

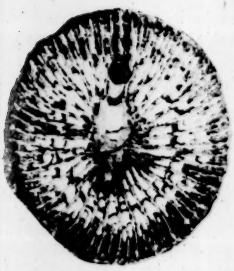
(To be concluded in the next Number.)

IV.—*UINTACRINUS* IN THE RINGWOULD AREA, NEAR DOVER.

By Dr. ARTHUR W. ROWE, F.G.S.

WHEN we were gathering material and data for that portion of the paper on Kent and Sussex[1] dealing with the Dover section we made careful search for *Uintacrinus* both on the top of the cliff, north of St. Margaret's Bay, and on the high ground immediately to the westward of the cliff. We failed to find it in either situation, and there were no quarries close to the coast. A thick tabular band of

[1] "The Zones of the White Chalk of the English Coast": Part 1, Kent and Sussex: Proc. Geol. Assoc., vol. xvi, part 6 (1900).



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1a

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3a

3b

3c

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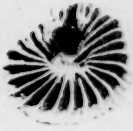
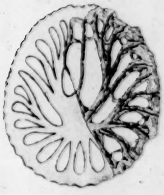


5a

6

6a



6b

7

Figs. 1-4. *Zaphrentis konincki*, Edw. & H. Figs. 5-7. *Z. delanouei*, Edw. & H.

CARBONIFEROUS LIMESTONE.

flint is seen at the top of the cliff at the north side of St. Margaret's Bay, and this we believe to be the same table of flint which we have called in Thanet the "Whitaker 3-inch tabular band." If our inference be correct, we are here within 21 feet of the "Barrois sponge-bed," which forms the basement-bed of the *Uintacrinus*-band in Thanet.

In the Autumn of 1902 we determined to examine all the pits in this area which were situated on sufficiently high ground to afford a chance of finding this crinoid. In walking from Dover to Walmer we passed through Ringwould, which is 1½ miles south of Walmer and the same distance west of the coast, and decided that, as it was on the highest ground in the district, on the 200 feet contour-line, and sufficiently far from the coast to bring up the bed in question, it was here that our quest should begin. We found *Uintacrinus* in the pit called The Hooketts, at Ringwould (Pit No. 84 of this paper), but had no time to follow up the search on that occasion. However, we took characteristic body-plates and brachials to General C. F. Cockburn, of Dover, and asked him to continue the examination of this limited area. This he did with such good success that he was able to add the pits at Appleton Farm, Court Lodge Farm, as well as those north-west of Longelose Wood and north of Ripple Cross, to the list.

Standing on the high ground at Ringwould, it is clear that we are on a ridge, and that the ground falls away in all directions save that on the south-west, where the village of Martin is situated. Parallel with the Ringwould ridge, and between it and the sea, is another ridge, the northern extremity of which is called Wood Hill, and the centre of which is known as Free Down. A glance at the map (Ordnance Survey, 6 inch, Sheets 58 S.E. and 58ª S.W.) will show that both these ridges are surrounded by the 200 feet contour-line. It is obvious, then, that our work lies along these two ridges.

A large number of pits have been examined between Walmer and Dover by General Cockburn and ourselves, and the numbers given simply indicate the order in our notebooks in which the quarries were examined. The two pits in the valley separating the Ringwould and Free Down ridges are situated in the zone of *Micraster coranguinum*.

We now give the pits in the *Uintacrinus*-chalk and the list of fossils obtained in them.

No. 1. We have here three small roadside exposures on the hill leading from Martin Mill Station to the village of Martin. The flints are in the form of rather small scattered nodules, mostly with thin cortices, but a few have thicker cortices. Between us we have examined these little exposures four times, and the only indication of *Uintacrinus* is a single body-plate found by General Cockburn. The other noteworthy occurrences are *Actinocamax verus*, *Conulus conicus*, and *Rhynchonella plicatilis*. The thick cortex of some of the flints is suggestive of the zone of *Micraster cor-anguinum*, and but for the plate of *Uintacrinus* we might possibly have felt inclined, on purely lithological grounds, to have placed the lowest of these little sections in the upper limit of that zone. Those who are familiar with the coast-section at Kingsgate in Thanet, however, will remember that

Uintacrinus and *Actinocamax verus*[1] extend to within a few feet of the base of the *Uintacrinus*-band, and that there *Rhynchonella plicatilis* is limited to the base of the sub-zone in question. It is reasonable, therefore, to suppose that we have here the base of the *Uintacrinus*-band exposed, and not the top of the zone of *Micraster cor-anguinum*. We saw no evidence of the "Barrois sponge-bed" which divides the two zones in Thanet. The three fossils quoted above are of the twelve species collected here alone of zonal value.

No. 2. A pit in a coppice about 300 yards west of the northern end of Longclose Wood. It is near a trigonometrical station on the 240 feet level. Of the thirteen species collected here *Uintacrinus* and *Actinocamax verus* are alone useful for zonal purposes, and the former was found in abundance.

No. 3. This is a pit of fair size north of Appleton Farm, one-third of a mile north of the village of Martin. It is in a flintless area of *Uintacrinus*-chalk, and the name-fossil is abundant. We obtained a list of nineteen species here, but the only forms characteristic of the sub-zone are *Actinocamax verus*, the nipple-shaped head of *Bourgueticrinus*, the large form of *Porosphæra globularis*, and *Infulaster rostratus*. A rostrum of the last-named rare echinid was found by General Cockburn.

No. 4. There is no pit here, but only a few inches of broken-up chalk exposed on the eastern side of the road, which runs by the eastern side of the reservoir at Martin. Here we were fortunate enough to find *Uintacrinus*.

No. 5. An old pit on the western side of Leeze Wood, Martin, is certainly in the same horizon, but it is now covered by grass and bushes. A few pieces of chalk were lying on the grass, and in these we found fragments of *Echinocorys*, as well as *Cidaris perornata*, *Terebratulina striata*, and *Ostrea vesicularis*; but *Uintacrinus* could not be seen. There can be no doubt, however, as to the age of this chalk.

No. 6. A very small, badly exposed pit at Court Lodge Farm. This also yielded *Uintacrinus* in fair abundance, but we found no other zonal fossils.

No. 7. In a pine plantation, 300 yards north-east of Ripple Cross, there is a small pit in flintless chalk which gave us nine species. Of these *Uintacrinus* and *Actinocamax verus* are alone worth quoting.

No. 8. An old pit at a place called "The Hooketts," one-fourth of a mile south of Ringwould, with seven small square caves hewn in the surface. A few nodular flints are seen here. This exposure gave us our longest list (27 species); it is the place where we originally found *Uintacrinus* in this area. The crinoid is abundant and *Actinocamax verus* not uncommon. In addition we found two examples of the nipple-shaped head of *Bourgueticrinus*, and Mr Sherborn obtained no less than three rostra of *Infulaster rostratus* in one day. Such a stroke of good fortune can hardly have occurred before to any other collector in this sub-zone in the South of England. The large form of *Porosphæra globularis* was found; and an example of *Lima decussata* is from its comparative rarity sufficiently interesting to be worthy of notice.

[1] Op. cit., pp. 296–300.

No. 9. This is a small and much obscured pit behind the Wheat Sheaf Inn at Martin. The flints are in the form of large and smooth nodules, and they do not run in courses. We were quite content to find *Uintacrinus* and the large *Porosphæra globularis* in a list of only six species.

This completes the workable exposures surrounded by the 200 feet contour-line on the Ringwould ridge. It will be seen that every pit is in the *Uintacrinus*-chalk.

We now cross the valley between the Ringwould and Free Down ridges, passing on the way two poor exposures in the *Micraster cor-anguinum*-zone at Great Coombe. The flints here are quite different, being in courses, more rugged in shape, and with thicker cortices. Moreover, the scanty fauna was that of the zone just mentioned.

No. 22. Ascending the Free Down ridge, we make for the east side of Wood Hill to examine an old chalk-pit, and find that it is completely overgrown with vegetation. By good fortune a new estate is being laid out on the southern slope of this ridge, and in Victoria Road a pit has been opened for the purpose of road-making. The flints are here in the form of large smooth nodules, like huge potatoes, and we found not a few plates and brachials of *Uintacrinus* on them, as well as in the chalk itself. Out of seventeen species obtained here only the name-fossil and *Actinocamax verus* were of zonal value.

No. 18. The railway made by the contractors to the new Harbour Works, for the purpose of bringing ballast from Stonor, skirts the northern edge of Langdon Hole, which is a deep coombe situated midway between the east side of Dover and the South Foreland light-house. Above the north-eastern corner of Langdon Hole the line emerges through a short and shallow cutting which exhibits the usual broken-up surface chalk. Knowing that a considerable thickness of the *Micraster cor-anguinum* zone is exposed in Langdon Stairs, and that the railway cutting through the top of the cliff called the Cobbler passes through the same chalk, it occurred to General Cockburn that this insignificant little exposure at the north-eastern corner of Langdon Hole was at a sufficient elevation to bring in the *Uintacrinus*-band. He examined it and found the crinoid in abundance.

We visited this section with General Cockburn at a later date, with the result that our combined collecting furnished a list of 36 species, among which we record the nipple-shaped head and barrel-shaped columnar of *Bourgueticrinus*, the pyramidal shape-variation of *Echinocorys scutatus*, *Infulaster rostratus*, *Micraster cor-anguinum*, *Conulus conicus*, *Cyphosoma corollare*, *Terebratulina rowei*, *Kingena lima*, *Terebratulina striata*, *Rhynchonella plicatilis*, *Actinocamax verus*, *Pecten cretosus*, *Pecten quinque-costatus*, *Ostrea vesicularis*, *Ostrea wegmanniana*, *Spondylus latus*, *Inoceramus cuvieri*, *Lima hoperi*, *Lima decussata*, *Porosphæra globularis*, *P. pileolus*, *P. patelliformis*, *P. arrecta*, and *Spinopora dixoni*. We give the more important fossils found here, as this list is characteristic of the fauna found in the other pits.

No. 11. In 1906 General Cockburn and Mr. Sherborn examined a recently cut trench, 30 feet deep and 400 yards long, at the site of the Duke of York's Schools, between Lone Tree on the Deal Road and Frith Farm on the Guston Road, Dover. No contour-line is given,

as this spot is in the neighbourhood of a fortress. There is here a section in the *Micraster cor-anguinum*-zone, with a thin capping of the *Uintacrinus*-band. Three brachials of this crinoid, but no body-plates, were found, and out of a list of 15 species we mention *Actinocamax verus*, the large dome-shaped form of *Echinocorys scutatus*, *Conulus conicus*, *Micraster cor-anguinum*, *Rhynchonella plicatilis*, *Pecten cretosus*, and *Pinna decussata*. The last-named rare fossil came from the lower zone and is a new record for the district.

We may mention incidentally that in visiting the estate called Higham, on the high ground to the east of Bridge, we found *Uintacrinus* abundantly in a little pit in the private grounds. It is clear, therefore, that the stretch of country lying between Ringwould and Higham would be worth searching for this crinoid wherever the ground stands sufficiently high to make the quest possible.

Not only are the foregoing observations useful as a record of an occurrence of the *Uintacrinus*-band, hitherto unknown, but they afford some interesting information in relation with the lithological and zoological conditions in that sub-zone.

In Thanet, with the exception of the 'Bedwell-line,' which is a scattered band of smooth nodular flints dividing the *Uintacrinus*-band from the *Marsupites*-band, flints are notably rare. In the *Uintacrinus*-chalk of the Ringwould area, however, flints are nearly always present, and often of considerable size. Though they are rather irregular in shape, they are generally smooth nodules with practically no cortex, and no tendency to run in courses, thus affording a marked and useful contrast to the notably irregular flints of the zone below, where the flint courses succeed one another at regular intervals and the cortices are quite thick.

This variation of the flints in the *Uintacrinus*-band is but another instance of lithological change in a relatively short distance, for Ringwould is only 10 miles from Pegwell Bay. We have pointed out these local variations in every county with which we have dealt, and are more than ever convinced of the unwisdom of relying on lithological data alone.

Zoologically, the chief point of interest lies in the fact that the fauna of the two districts is identical. For, as in Thanet, we found *Actinocamax verus*, the nipple-shaped head of *Bourgueticrinus*, the pyramidal shape-variation of *Echinocorys scutatus*, *Terebratulina rowei*, and the large form of *Porosphæra globularis*. The shape-variations in *Conulus* seem also to be the same as those in the Island. We found no fragment of *Ammonites leptophyllus*, but obtained four examples of *Infulaster rostratus*, which is a notably rare fossil in Thanet. This echinid must be not uncommon in the Ringwould Chalk, for it is only on these grounds that we can explain the discovery of four minute rostra in sections so poor and obscured by rainwash.

Not one of these sections presented a clean surface, and most of them were very small. In spite of these difficulties we were able to obtain a list of 60 species for the whole area.

V.—*Actinocamax verus* in the Upper Part of the *Micraster cor-anguinum* Zone at Walmer and St. Margaret at Cliffe.

By Dr. Arthur W. Rowe, F.G.S.

THE known occurrences of *Actinocamax verus* in this zone are comparatively few. Northfleet in Kent, Micheldever in Hampshire, and Great Fimber in Yorkshire are our only records.

When we were examining the cliff between Kingsdown and St. Margaret's Bay we searched for it in vain. In November, 1901, however, General Cockburn showed us several examples which he had obtained in the pits by the waterworks at Walmer, together with the fossils associated with them. From an inspection of the latter we had no doubt that they were derived from the upper part of the *Micraster cor-anguinum*-zone rather than from the *Uintacrinus*-band. However, to place the matter beyond doubt, we went to Walmer and found that the pits were hewn in massive chalk, with regular bands of compact black flints, corresponding in every way to those on the coast at Kingsdown.

From these pits we obtained two examples of *Actinocamax verus*, the characteristic shape-variation of *Echinocorys scutatus*, *Micraster cor-anguinum* and the var. *latior*, *Conulus conicus* and *C. albogalerus*, the characteristic head and columnars of *Bourgueticrinus*, and *Cidaris perornata*.

There is a pit at East Valley Farm, on the 200 feet contour-line, and a mile north of St. Margaret at Cliffe. The flints are in bands, and not very numerous, but they are more irregular than those found in the *Uintacrinus*-band, and have thick white cortices. From the lithological standpoint we should infer that we were in the highest part of the *Micraster cor-anguinum* zone, and at a higher level than the Walmer pits. A long and careful search failed to demonstrate the presence of *Uintacrinus*. We found *Actinocamax verus*, the characteristic shape-variations of *Echinocorys* and *Bourgueticrinus*, *Conulus conicus*, *Micraster cor-anguinum*, *Cyphosoma Königi*, *Cidaris perornata*, *C. clavigera*, *C. hirudo*, *C. sceptrifera*, *Kingena lima*, *Notidanus microdon*, and *Porosphæra globularis*, of the size associated with the zone in question. There was no sign of the "Whitaker 3-inch band" or of the "Barrois sponge-bed."

It may be of interest to those who follow the distribution of Cephalopoda in this zone to mention that since the publication of the paper on Kent and Sussex we have found four Ammonites of the *leptophyllus* group in falls from the *Micraster cor-anguinum*-zone on this coast. We have also seen one *in sitâ* at Joss Bay, Kingsgate, Thanet, 10 feet below the "Whitaker 3-inch tabular-band," and therefore 21 feet below the junction with the *Uintacrinus*-band. We know also of four examples in the Northfleet pits.

We put on record these zonal notes in the hope that those resident in the Dover area will extend our obviously sketchy and imperfect examination of the district. Indeed, the work was done in a few brief hours snatched from the more important examination of the cliffs, and but for the able assistance of General Cockburn would not have been worth publishing.

VI.—Notes on the Drift and Underlying Deposits at Newquay, Cornwall.

By B. B. Woodward, F.L.S., F.G.S., etc.

(*Concluded from the January Number, page* 18.)

FROM the point K northward to the stile leading to the road on to the Towan Head the killas comes to the top, but just short of the stile there is a section of another hill-wash-dune showing about 5 feet, but not exposing the base. Land shells are abundant towards the top, especially at 1 ft. 3 in. and 2 feet from the surface, but the lower portion contains very few. The *Helix nemoralis* zone lies just below. This section yielded the flint flake found by Mr. Warren.

Immediately on crossing the stile a deep narrow cove comes right up to the path on the left-hand side, and on the top of a thin layer of 'head' which caps the killas the base of the *Helix nemoralis* zone can be seen. It consists of reddish ochreous earth, with fragments of *Mytilus*, shells of *Patella*, and burnt (?) stones, passing up into sand with land shells. The greater portion of the zone, however, forms the floor of the path. Between the latter and the head of Hedge Cove on the east side of the neck of land (where is the quarry section noted by the writer in 1900) is a big hill-wash-dune divided by the road. The section on the east side (T), which was clear in 1900, is now nearly all talus. A small patch of *Mytilus*, 1 foot from the top, appears at one point.

The floor of the ledge by which this section is approached is formed by the *Helix nemoralis* zone, which is perfectly visible in the cutting leading down into the cove as well as in the edge of the ledge, and it is separated from the killas by only about 6 inches of 'head.' It consists at the base of reddish ochreous loam passing up into somewhat firm yellow sand that contains many shells common to the later phase, notably some very fine *Helicella barbara*. In this it resembles the section at E. The zone was also traceable round the seaward face of the dune.

Opposite the Lifeboat House in the sides of the cutting for the lifeboat slip, the zone is again shown, reddish ochreous in colour, but containing no shells, while there are but few molluscan remains in the 2 to 3 feet of overlying, later-date sands.

Just north of the Lifeboat House a deep gully cut right down to the old platform (?) runs right athwart the neck of land, and is crossed by a narrow bridge. The *Helix nemoralis* zone crops out on both sides of this gully and is of reddish ochreous colour, about 1 foot thick. On the west side of the bridge (M) it was full of shells (see table, p. 84), but on the east side was barren. This is Mr. Warren's point 'D.'

On the west side next the Lifeboat House the zone is overlain by masses of broken slate, probably the result of building operations, for on the east side about 2 feet of hill-wash-dune caps it.

Immediately on crossing the bridge the zone is seen on the surface just where a slope leads down into the gully; here one type shell occurred. Three yards on, the zone appears in the side of the path to the beach (N), and is about 9 inches thick, but contains no shells,

being full of rock-fragments and looking as if composed, as it probably is, of re-made 'head.' It is capped by 15 inches of hill-wash-dune with land shells, and at the base *Patella*. Over all is a layer of slate fragments 4 to 6 inches thick immediately succeeded by the turf.

This is Mr. Warren's furthest north and his starting-point.

Careful search, however, did not result in the finding of any more pieces of pottery.

On either side of the path to the top of the headland are further remains of hill-wash-dunes with land shells, but they cease in a few yards, and all over the headland the surface soil, which is about 9 inches thick, resting directly on the killas, contains no remains of shells whatever, though snails live on the spot. The same is the case on East Pentire headland.

Following round the west side of the Towan Head the next section is beside the path (O) leading to the ruin of the old quay. Here there is a sandy seam resting on the killas and overlain in places, especially at the point P, by slate rubble. At the top of this seam at one spot were some burnt slates and a few shells of *Purpura* and *Mytilus*. A deep fissure in the killas was filled as follows:—

		ft.	in.
1.	Sand seam	0	9
2.	Sand with fragments of slate and rock: the equivalent, seemingly, of the 'Head'	6	0
3.	Indurated sands, showing current bedding	15	0

These rest on an old platform of killas rising 8 to 10 feet from a second platform of the same that is raised 10 to 15 feet above the beach below.

Yet a little further north a sloping path (Q) leads into an old quarry in the cliff. Between P and Q, under about 2 feet of top soil, there appears to be about 4 feet of 'head,' or its equivalent, and beneath this some 20 feet of indurated sands, deposited over and between projecting reefs of killas.

Where the path begins to descend the upper portion of the section is obscured by a talus of slate rubble, and similar rubble caps the killas in the quarry (R).

Under the path the indurated sands are extensively piped. Most of these are filled with ordinary earth, but three or four contiguous pipes contained a purer sand than seen elsewhere, full of land shells, the wrecks of some deposit of which no trace now remains above. The molluscan fauna gathered here differed markedly from collections made elsewhere in the neighbourhood, as will be seen from the list given in the table (p. 85). The bulk is made up of a high-spired variety of *Helicella virgata*, having a single peripheral band. Of these 1,186 specimens were counted, while there are only 16 having more than one band and 127 without any.

No dune deposits exist over the northern part of the Head, but on the eastern side at a point (S) nearly exactly opposite to Q, there is a small cirque sloping down to the sea. By the edge of the path that runs round it about half-way up, the soil exposed is seen to consist for the most part of slaty rubble, but almost in the centre of the cirque there is an inlet, or pipe, of sandy material with land shells.

Except for the presence of *Helicella barbara* and the absence of *Jaminia cylindracea*, the fauna bears a resemblance to that found at Q. The former species may indeed be only adventitious, for the mollusc lives on the spot and has a quaint habit of rolling down into places where it has no business.

On the rocks below, traces of the coarse pebble beach, but no indurated sands, were observed.

Retracing one's steps southwards past the Lifeboat House and going down the eastern side of the headland, the quarry (U) over Seal Hole is reached. Here a foot or so of 'head' is covered by a like amount of hill-wash-dune with shells, including a stray *Helix nemoralis*.

At the south end of the quarry where the path leads down (V) another hill-wash-dune is cut into. This contains a few land shells of the species most characteristic of the upper series (see table, p. 85).

Descending to the base of the cove, the old marine platform is found exposed with the coarse pebble beach resting on it, while projecting through the talus of tumbled top soil that curtains the steep slope, masses of the indurated sands are seen, and round the corner of the south end of this section a big mass of these sands showing current bedding is visible, stacked between two reefs of killas, in a position impossible for a blown sand to assume (Fig. 2).

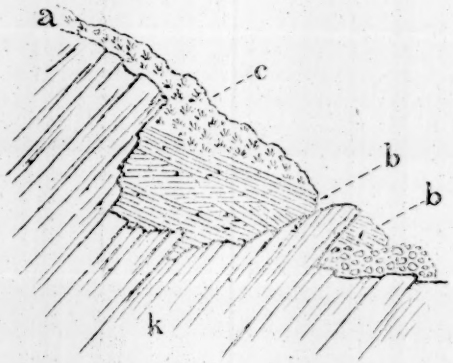


Fig. 2.—Diagrammatic sketch of the south end of the Raised Beach by the Seal Hole. *k*, killas, rising to near the surface at *a*, where it is overlain by a hill-wash-dune. *b*, *b*, denuded masses of the indurated marine sands, resting to the right on the remains of the coarse pebble beach. *c*, curtain-like talus of top soil.

Judging from the species of shells found in the base of the talus (see table, p. 84), the *Helix nemoralis* zone would seem to have been represented on the spot.

No further sections were noted till the cliff to the east of the Atlantic Hotel by Pigeon Cove was reached. On the north side of the Cove (W) the old platform is some 15 feet above the sea with the coarse pebble bed resting on it, capped by about 15 feet of indurated sands. Above these, again, there is a very coarse, hard, solid breccia, 2–3 feet thick, which seems to have escaped the notice of previous observers. It is quite different from any other rock in the vicinity, though it may be the local equivalent of the 'head.'

On the south side of the Cove (X) the pebble-beach is again met with on the platform, while the indurated sands above seem partly eroded, but mostly masked by slips of the top soil. The southern ascent from this spot to the projecting point (Y) is capped by a hill-wash-dune containing a few land shells of the modern type. The talus, which stretches right down the face of the cliff here, is derived from this dune. The platform is again well seen at the base of the cliff on the south side of this point.

Just beyond to the south is an inaccessible shelf-like promontory, reaching half-way up the cliff and covered with bracken and ferns. Save for a few stunted examples by the wall of the ruined fish cellars on Towan Head, this is the only spot on the headland where the bracken can be seen.

No shell-bearing beds occur to the south of this, but there is a patch of 'head' to be seen filling a hollow in the killas above the eastern end of the recess in Town Beach occupied by the Laundry (Z).

One other locality remains to be mentioned. On the slope of the hill rising from the town to the top of the golf links on the south side of Crantock Street and just opposite the opening of Jubilee Avenue, a pit (7) in a field shows 6 feet of sand with land shells belonging to the last phase of the hill-wash-dunes. The bottom of this deposit is not shown, while the surface simply forms part of the general hill slope and gives no indication of its probable extent. The source of this sand is presumably Fistral Bay: it shows but little hill-wash soil in its composition.

A word as to the age of these deposits. The hill-wash-dunes are mainly, if not altogether Holocene. Whether any portion of the *Helix nemoralis* zone at their base be Pleistocene is not clear, though if the human vestiges should prove to belong to the Palæolithic period some part would be. The molluscan remains shed no light on this question.

The 'head' is manifestly the local representative of the cold period known in other parts of the country as Glacial.

Then as to the old marine (mostly indurated) sands that underlie the 'head.' These are nowhere, as some have asserted, interstratified with the 'head.' Nor are they 'blown sands.' They compare in composition very closely with the existing sands of the foreshore of Fistral Bay,[1] and are coarser than the sands found in the hill-wash-dunes, or than those at Perranzabuloe, judging from specimens kindly sent me by Mr. G. Earthy for comparison. Their bedding planes, except of course where current action is shown, slope seawards, just as the present beach does. Dr. Paris[2] aptly, so far as the rock is concerned, compares them to the celebrated Guadeloupe specimen containing the skeleton, and hunted in vain for human remains in them. Where these indurated sands rest directly on the irregular surface of the killas they are bedded in among the interstices as a water-deposited sand would be and as a blown sand deposit would

[1] I have to thank my young friend Miss Dorothy Joos for sending me on samples of these.

[2] Trans. Roy. Geol. Soc. Cornwall, vol. i (1818), p. 6.

TABLE SHOWING THE MOLLUSCAN FAUNA OF

Species.	Helix nemorális Zone. A B	D	E F	T	M
Milax Sowerbyi (Fér.)	...	...	...	...	...
Vitrina pellucida (Müll.)	...	...	...	...	...
Vitrea lucida (Drap.)	4	1	3	1	...
V. cellaria (Müll.)	3	...	...	...	...
V. nitidula (Drap.)	7	...	24	...	...
V. radiatula (Alder)	...	1	...	...	1
Arion ater (Linn.)	*	...	...	...	*
Pyramidula rotundata (Müll.)	18	3	34	...	10
Helicella virgata (Da C.)	5	...	12	...	...
H. itala (Linn.)	...	...	...	...	...
H. barbara (Linn.)	10	...	...	4	...
Hygromia granulata (Alder)	4	...	...	...	...
Acanthinula aculeata (Müll.)	1	...	...	...	...
Vallonia pulchella (Müll.)	4	...	8	...	...
Helix aspersa, Linn.	...	...	...	...	...
H. aspersa, spicula amoris	...	...	...	...	...
H. nemoralis, Linn.	32	12	92	18	81
H. nemoralis, spicula amoris	...	...	3	...	...
H. hortensis, Müll.	...	4	...	...	3
Cochlicopa lubrica (Müll.)	13	...	4	2	...
Jaminia cylindracea (Da C.)	...	...	...	...	...
J. muscorum (Linn.)	3	...	1	...	...
Vertigo pygmæa (Drap.)	1	...	...	...	...
Clausilia laminata (Mont.)	...	...	1	...	...
C. bidentata (Ström)	...	...	1	...	...
Carychium minimum, Müll.	2	...	3	...	2
Pomatias elegans (Müll.)	...	...	13	...	...
Total ... 25	107	21	199	25	97
Purpura lapillus (Linn.)	...	...	*	...	*
Turbonilla?	...	...	...	...	...
Rissoia parva (Da C.)	...	...	...	...	1
Littorina obtusata (Linn.)	...	...	...	...	...
Gibbula umbilicata (Mont.)?	...	...	...	...	...
Patella vulgata, Linn.	...	...	*	*	*
Venus verrucosa, Linn.	...	...	...	...	...
Lassæa rubra (Mont.)	...	...	...	...	1
Ostrea edulis, Linn.	...	...	...	...	...
Mytilus edulis, Linn.	...	...	*	...	...
Glycimeris glycimeris (Linn.)	...	...	*	...	...

THE HILL-WASH-DUNES NEAR NEWQUAY.

Age Doubtful.			Holocene.						
				F L.					
Q	S	V (base)	*Mytilus* band at K.	Below upper *Mytilus* layer.	Above upper *Mytilus* layer.	V (top)	A–B	5	Total.
...	...	...	...	...	...	...	...	1	1
...	...	1	...	...	...	...	...	...	1
...	...	...	...	...	...	...	...	...	9
v.	...	1	...	...	...	...	...	...	4
...	...	...	...	...	...	...	...	...	31
...	...	...	...	...	5	...	...	...	7
...	...	...	*	*	*	...	*	*	*
...	...	...	...	...	...	...	...	...	65
1329	117	45	...	4	80	127	323	145	2187
...	...	23	91	869	923	46	454	131	2540
...	5	5	32	148	158	150	202	120	834
...	...	3	...	8	...	1	...	...	16
...	...	...	...	...	...	...	...	...	1
...	...	...	3	101	58	...	32	8	214
...	...	1	...	...	3	...	...	2	6
...	...	...	...	...	1	...	...	1	2
16	2	5	...	2	3	...	1	...	264
...	...	...	...	...	...	...	...	...	3
...	...	...	...	...	...	...	...	...	7
5	4	1	21	86	56	...	17	3	192
10	...	2	...	...	...	...	...	...	12
8	2	...	7	83	63	...	56	4	207
...	...	...	...	2	5	...	...	1	9
...	...	...	...	...	...	...	...	...	1
13	2	...	...	...	1	...	...	...	17
...	...	...	...	...	...	...	...	...	7
...	...	...	...	...	...	...	...	...	13
1381	132	87	154	1303	1356	324	1065	419	6650
...	...	...	*	...	...	...	*	...	...
2	...	...	...	...	...	...	...	...	...
1	...	...	...	...	...	...	...	...	...
*	...	...	...	...	*	...	*	...	...
1	...	...	...	...	...	...	...	...	...
*	...	*	*	*	*	...	...	...	...
...	...	...	...	1	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
...	...	*	...	...	...	...	...	...	...
...	...	*	*	*	*	*	*	*	...
...	...	...	...	...	...	...	...	...	...

not be. They contain no angular fragments of rock, all such large pebbles as they enclose being well rounded, while the few fossils that have been found genuinely embedded in them are marine.[1]

The coarse pebble beach at the base contains well-worn fragments of rock; the bulk, of vein quartz, is of local origin, but, according to Mr. Clement Reid, who has studied them, there is a considerable admixture of rocks not traceable in the immediate vicinity. Mr. Reid postulates ice for their transport, but has to invoke many hypotheses to buttress this contention, while he is obliged to admit that the fossils indicate a temperate period. He even refers to this raised beach a big greenstone boulder found on the beach at the southern end of Fistral Bay; had he searched the cliff above he would have found in the 'head,' a much more likely source, boulders to compare with it in size.

To the writer a more simple explanation, demanding but a single hypothesis, is that these fragments were derived from contiguous rocks that have been removed in the formation of the present coastline.

It is evident that a vast interval of time must have been consumed, first in the excavation of the old bay and the wearing down of the killas to form the old platform (possibly with the assistance of the pebbles that afterwards went to form the beach immediately lying thereon), then in the production and piling up of the marine sands to a depth of 20 feet before the 'head' period. Under these circumstances a greater age must be attributed to this set of deposits than has hitherto been granted, so that one would not be surprised if they ultimately were referred to the Pliocene. There is nothing in the few fossils they contain to disprove this.

With regard to the molluscan fauna of the hill-wash-dunes, the accompanying table speaks for itself. Twenty-five species are here recorded, as against seventeen in Mr. Warren's list.

Mr. A. S. Kennard has most kindly assisted in the case of critical specimens and undertook to search the material for slug remains: those given are all of his finding. To Mr. E. A. Smith, I.S.O., I am indebted for the determination of the smaller marine species.

No particular attention was given to the marine forms and no register kept of their number where more than a chance specimen was present: their occurrences are consequently marked in most cases solely by an *.

It is also impossible to attach a number for the calcareous grains that represent the shell in *Arion*, since they stand for an uncertain quantity, hence in their case too an * is employed to mark their occurrence.

The division of the species into 'woodland' and 'sand dune' is a matter of assemblage rather than an individual quality, and has not been attempted. If, however, the species recorded for the *Helix nemoralis* zone be scrutinized, it will be manifest at once that they as an assemblage differ from the group of forms from the upper beds and

[1] The ox bones cited by De la Beche (Rep. Geol. Cornwall, etc., pp. 427–8) obviously came out of one of the pipes, as also must the portion of red-deer's antler recorded and figured by Borlase, Nat. Hist. Cornwall, p. 281, pl. xxvii, fig. 5.

contain more of the sylvan and moisture loving species. As a matter of fact, the species taken as the type of the zone on account of its greater prominence is not confined to that period, but is still living on the spot, e.g. the grassy slope in the southern angle of Fistral Bay. Some examples of this species from the zone have the thickened shell so characteristic of those from Dog's Bay, Ireland.

The forms that so far appear restricted to the zone are *Vitrea lucida*, which has not hitherto been recorded fossil, *Pyramidula rotundata*, *Acanthinula aculeata*, *Helix hortensis*, *Clausilia laminata*, *Carychium minimum*, and *Pomatias elegans*. Those found only in the upper beds are *Milax Sowerbyi*, *Helicella itala*, and *Helix aspersa*; while peculiar to the beds of doubtful age are *Vitrina pellucida* and *Jaminia cylindracea*.

The mode of occurrence and recurrence of the layers of *Mytilus* shells calls for some further explanation than can at present be offered. They occur at such defined intervals, and, if synchronous in the several dunes, are spread over such a considerable area, that they appear to mark epochs of some sort. The thicker patches and, of course, the cooking sites indubitably speak of Man, but the persistent thin upper seams, and especially the top one in each section, even if those in the different dunes do not correspond in time, seem to suggest some other agency than Man needful to account for their being thus evenly spread out. Do they, perchance, indicate periods of dearth of other food during which crows and gulls were driven to subsist mainly on mussels and carried them up on the dunes to devour?

Another point of interest is the wonderful state of preservation of the molluscan shells in the dunes, wherein they occur quite perfect from the base right up to the turf, whereas when the slates come to the top, save for a foot of soil, that soil never contains the trace of a shell, though snails are living on the spot and must have done so for ages. This is the case both on Towan Head itself and on East Pentire Headland. The explanation seems to be that where the drainage is uniform and perfect the percolation of rain-water has little, if any, effect on the shells, whereas when there is no such complete drainage the soil retains the moisture longer and the shells are macerated and dissolved, just as they are when the drainage is diverted and concentrated in channels and pipes.

REVIEWS.

I.—Ancient Britain and the Invasions of Julius Caesar. By T. Rice Holmes, Hon. Litt. D. (Dublin). 8vo; pp. xvi, 764, with 3 maps and 44 text-illustrations. Oxford: at the Clarendon Press, 1907. Price 21*s.* net.

THE object of the present work is "to tell the story of man's life in our island from the earliest times"; and as the author has endeavoured "to treat it comprehensively from the beginning to the Roman invasion of A.D. 43," it has a direct bearing on the later

chapters of geology. In his interesting introductory sketch of the progress of research, the author pays tribute to Sir Richard Colt Hoare and William Cunnington (sen.), with whose labours in Wiltshire "the era of scientific investigation may be said to have begun." From the materials since accumulated, by Prestwich, Pengelly, Sir John Evans, Lord Avebury, Canon Greenwell, Pitt-Rivers, Professor Boyd Dawkins, E. B. Tylor, and many others, it is considered that we know enough about sepulchres, skulls, coins, about implements, weapons, ornaments, urns, place-names, and folklore, "to justify an attempt to create a synthetical work, the aim of which shall be to portray in each successive stage and to trace the evolution of the culture—nay, in some sort even to construct a history—of prehistoric Britain." With this aim we are in full sympathy. A judicial summary of our knowledge is ever an advantage to progress, and we agree with the author that "Not only is the subject fascinating; it is an indispensable introduction to the history of England."

That much remains to be learnt is freely admitted by the author. Following the Introduction he deals with the Palæolithic age, and with "those who, in hard struggle with nature and with fierce beasts, were the unconscious founders of European civilization." Here we are brought face to face with many controverted questions, with the relations of man to the Glacial epoch and with his origin. Palæolithic implements identical in form and character with British specimens, fabricated perhaps at widely separated periods, but many of them of great antiquity, have been found in various regions of the world; but "the original home of the race is unknown."

The author gives a good account of the main features of the Ice Age as interpreted by geologists; a task by no means easy, considering the divergence of views on the extent of ice-sheets, on movements of upheaval and depression, and on interglacial periods. Here indeed, as elsewhere, we may compliment him on his impartial treatment, his laborious research, and the full references he gives to the views of others, whether or not he agrees with them.

When man first entered Britain the whole country may have stood at least 600 feet above its present level, or it may have been no more than 70 feet. Thus at the start the author calls attention to contradictory views expressed in different volumes of the Victoria History of England. In the latter case it is supposed that man entered across a narrow strait formed during an early stage in the Glacial epoch, the channel having been cut by overflow from the north European drainage that was then barred from escaping northward by the North Sea ice-sheet.[1] A greater elevation than 70 feet, perhaps a subsequent elevation, seems needed to explain the deeply eroded channels filled with Glacial Drift that have been found in East Anglia.

There is still diversity of opinion with regard to the relation of the Mammoth to the Glacial period. It has not, however, been definitely obtained in any Pliocene deposit; even in the Cromer Forest-bed, although some specimens, as Mr. E. T. Newton has remarked,

[1] Cf. C. Reid, "Origin of the British Flora," 1899, p. 39.

"approach the *E. primigenius* type of tooth, none are precisely like any undoubted example of the species."[1]

Glaciated remains of mammoth have, however, been found, and it is not to be questioned that this animal existed in Britain prior to the period of maximum glaciation. That man similarly existed there is no reason to doubt. Remains of mammoth and other Pleistocene mammals are abundant in the Dogger Bank and in the Thames Valley gravels; and when these remains were accumulated a large part of the North Sea, as the author remarks, could not have existed, and there was a 'land-bridge' at any rate in that part of the Palæolithic age.

He does not attempt to connect this stage with that when the Straits of Dover began to be cut by overflow; and in a footnote referring to Mr. Clement Reid's remarks on the re-extension of the old Rhine estuary, he confesses he does not understand how to reconcile them. There is, however, no necessary want of discord.

That caves were occupied by man and by Pleistocene mammalia before the climax of the Ice Age is now admitted from evidence obtained not only in North Wales, but also, as regards mammalia, more recently by Mr. Tiddeman in the Gower promontory.

With regard to Eoliths the author speaks with reserve, remarking that "he who reflects that they have been met with not only in Tertiary beds but in those immeasurably later deposits which were contemporary with or but little older than Palæolithic man will leave them for the present without regret to the consideration of enthusiasts." Nevertheless, among those noted to have accepted these rudely shaped stones as artificial are Canon Greenwell, Pitt-Rivers, and Prestwich.

A great deal has yet to be learned about the successive types of Palæolithic implements, a subject brought before our readers by Mr. S. Hazzledine Warren (GEOL. MAG., 1902, p. 97); and we may add, much information is wanted also of the animal and other remains associated with them. Thus the Hoxne implements, regarded as of later date than the Chalky Boulder-clay, those of Caddington near Dunstable, and those found at various levels in the deposits of the Thames Valley, and elsewhere, have yet to be studied more particularly in reference to the sequence of Pleistocene events. Eoliths as well as palæoliths have been derived and re-deposited. As the author remarks, "the Palæolithic age was of such vast duration that before its close Britain may well have been invaded by new races"; but he admits that, despite some present difficulties, the French chronological classification of de Mortillet may "contain a measure of truth."

Comment is naturally made on the scanty evidence of human remains in Pleistocene deposits. Of the famous Neanderthal man, the author observes that the skull was capacious enough to lodge a brain as large as that of many a living savage; and trained observers have pointed out that skulls of like contour have belonged in modern times to men of considerable mental power." Quite recently Professor Sollas has remarked that "the Neandertal and Pithecanthropus skulls stand like the piers of a ruined bridge which once continuously

[1] "Vertebrata of the Pliocene Deposits of Britain": Mem. Geol. Survey, 1891, p. 47.

connected the kingdom of man with the rest of the animal world" (Phil. Trans., 1907, B, p. 337).

While there is much that is doubtful concerning the Palæolithic inhabitants of Britain, there are sufficient facts to enable the author to picture something of their mode of life and culture. He remarks that "the close of the British Palæolithic age is veiled in obscurity." Nevertheless, he is doubtful about any great break between that and Neolithic times; doubtful also as to the physical conditions, whether Britain was so upraised as to be almost connected with the Continent, as suggested by the depth of alluvium in many river-valleys and by the evidence of submerged forests. After reviewing the evidence he concludes—"Therefore those of us who cling to the belief that the Neolithic immigrants who first ventured to launch their frail canoes on the narrow Channel and ran them aground on the Kentish coast may have found the new-born island inhabited by men of an older race have some reason to show for our pious faith."

We do not propose to follow the author in detail in his accounts of the Neolithic and later ages. Nevertheless, his chapters are by no means devoid of geological interest in connexion with the physical features, the inhabitants, the flint-mines of Brandon and Cissbury, and the pit-dwellings.

In his account of the Bronze age he does not accept Sir Norman Lockyer's views regarding Stonehenge, nor does he agree in any respect with Mr. Clement Reid's views on the subject of Mictis, Ictis, and Vectis. Mr. Reid had assumed that they indicated but one island, the Isle of Wight; and that about 2,000 years ago the Isle of Wight, near Yarmouth, was connected with the mainland near Lymington by ledges of Bembridge limestone, which formed a natural stone-causeway, available at low-water for the transport of tin from Cornwall. Other observers on various grounds had previously suggested that Ictis, rather than St. Michael's Mount, was the Isle of Wight. Alfred Tylor, in 1884 (*Archæologia*, xlviii, pp. 230–6), had urged the claims of Bembridge and Brading Harbour as the port of Ictis. Our present author strongly condemns these suggestions, and, discussing the whole subject in considerable detail, maintains that the evidence favours the old view that St. Michael's Mount was the veritable Ictis. He agrees with Lyell, Pengelly, and Ussher, "that since the time when tin was shipped at Ictis, St. Michael's Mount has undergone no sensible change." Lyell had observed that "It still affords a good port, daily frequented by vessels, where cargoes of tin are sometimes taken on board, after having been transported, as in the olden time, at low tide across the isthmus." John Phillips, in a paper entitled "Thoughts on Ancient Metallurgy and Mining in Brigantia and other parts of Britain" (Proc. Yorksh. Phil. Soc. for March, 1848), concluded that at first "the only route for the tin of Cornwall to the Mediterranean was by sea to the western parts of Spain"; and that at a later period "the track by land through Gaul to Massilia was preferred." If we accept this view we need not disagree with the remarks of Alfred Tylor that tin was sometimes carried by coasting vessels from Cornwall to the Isle of Wight. This alternative method of transport

from Cornwall to the Isle of Wight is indeed referred to by Mr. Reid, and it appears more reasonable than the idea of transport across country from Devonshire and Cornwall; moreover, there is no need to invoke a land-connection at that recent period between the Isle of Wight and the Hampshire coast, if we accept St. Michael's Mount as the island to which tin was conveyed by the people of Belerium in wagons at low tide.

Dene-holes are briefly dealt with, and the author agrees that they were used as granaries and places of refuge. Other excavations by shaft and tunnel were undoubtedly used simply to extract chalk, but they are not dene-holes. In some cases, however, it seems probable, as at Chislehurst, that excavations by tunnel for chalk were made in a tract previously utilized for dene-holes.

The author discusses the configuration of the coast of Kent in the time of Cæsar, the Goodwin Sands, and Romney Marsh.

He gives reasons for deciding that *Portus Itius*, whence Cæsar sailed on both of his expeditions to Britain, was Boulogne; and he claims to have demonstrated "that he did land both in 55 and in 54 B.C. in East Kent—in the former year between Walmer Castle and Deal Castle, in the latter north of Deal Castle."

One further conclusion may be mentioned with regard to the site of the great Metropolis:—

"The very large number of Palæolithic implements which have been found in London and its environs prove that in the earliest times it was a centre of population; but it would hardly be safe to infer from the discoveries of bronze and iron tools and weapons and of British coins that the Romans found a town on the site. If there was such a town, it certainly had little political importance; for while numerous British coins issued from the mints of Verulamium and Camulodunum, not one has been discovered which bears the name of Londinium. Nevertheless, it may reasonably be affirmed that London existed before the Roman conquest; first, because the same advantages that attracted the traders of Rome would also have commended themselves to those of Britain; and secondly, I repeat, because it is improbable that a Celtic name would have been given to a town which the Romans had built upon a virgin site."

II.—Geology of Ontario.

IN a paper on the "Grenville-Hastings Unconformity" (16th Report of Bureau of Mines, Ontario, 1907), Messrs. Willet G. Miller & Cyril W. Knight claim to have proved that the Keewatin of South-Eastern Ontario is the oldest series in the region. "An ancient Keewatin lava has, in places, been subjected to little denudation before the deposition of the Grenville limestone, which fills the cracks and openings in the ropy surface of the lava. Unconformably above the Grenville limestones and Keewatin lavas or greenstones rest the conglomerates and other sedimentary rocks, including limestones, which the present writers class as Huronian. These conglomerates contain not only ordinary fragments of the Grenville limestones but 'eozoon'-like boulders as well, thus showing that the limestone is much older than the conglomerate." They have further found in the conglomerates pebbles of cherty and ferruginous rocks resembling those of the iron-ranges of Lake Superior, and derived from layers or

bands in the Grenville limestone. The Huronian in their classification stands for what heretofore has been called the Hastings Series. The Laurentian includes both the Keewatin and Grenville Series.[1]

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

I.—*December 18th*, 1907.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "Some Recent Discoveries of Palæolithic Implements." By Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., For. Sec. G.S.

By the courtesy of Mr. Worthington Smith, the author is enabled to call attention to some recent discoveries of Palæolithic implements on the southern borders of Bedfordshire and in the north-western part of Hertfordshire. In addition to the discovery of a Palæolithic floor at Caddington brickfield, at between 550 and 590 feet above sea-level, implements have since been found on the surface of the ground at 600 and 760 feet respectively; while a good ovate implement was found in thin, water-laid material, at 651 feet O.D. In Hertfordshire, Palæolithic implements have been found at Great Gaddesden, at a brickfield about 1½ miles north-east of Hemel Hempstead, and at Bedmond, 2 to 2¼ miles south-east of the last locality. The drifts which cap the hills in North-West Hertfordshire seem to be of very variable origin; and a great part of the material is derived from clay deposits of Eocene age, but little *remanié*. It seems to the author that it is safest not to invoke river-action for the formation of the high-level deposits, which extend over a wide area and are in the main argillaceous and not gravelly or sandy in character, but to adopt Mr. Worthington Smith's view that in early times lakes or marshes existed in these implementiferous spots, the borders of which were inhabited by Palæolithic Man. The evidence that he has brought forward as to the implements having, in some of the Caddington pits, been manufactured on the spot, most fully corroborates this view.

2. "On a Deep Channel of Drift at Hitchin (Hertfordshire)." By William Hill, F.G.S.

Evidence is given, from nine borings running along a line slightly west of north from Langley through Hitchin, of the existence of a channel of considerable depth, now filled with Drift, occupying the centre of an old valley in the Chalk escarpment, which may be called the Hitchin Valley. For the first 3 miles it appears to be contained within narrow limits, persistent ridges of Chalk occurring on each side, and it might almost be compared to a Chalk combe. At Hitchin, after passing between two Chalk knolls, its confines become less clear, and there seems to be some evidence of broadening as it emerges on to the Lower Chalk plain and leaves the higher ground of the main

[1] In connection with the above see report of paper by Professor F. D. Adams, Geol. Mag., Dec., 1907, pp. 574, 575.

Chalk escarpment. The greatest depth to which the channel has been proved is at a boring in Hitchin, where the Gault was reached beneath Drift at a depth of 68 feet below sea-level. That the channel flowed northwards and belonged to a 'subsequent' stream seems to be proved by the fact that at Bragbury End, the only place where a southerly stream could pass, the space between bare Chalk exposures is but 450 yards, and in about the middle of the space Chalk has been reached within 50 feet of the surface (that is, about 200 feet above sea-level) in a well dug a few years back. The channel must be older than the Chalky Boulder-clay, which still partly fills it as far south as Langley, and may have blocked it to the southward and given rise to the features now presented in the drainage on the northern slope of the escarpment. But the author is inclined to suggest that either glacier ice or bay ice must have played no unimportant part in damming up the old valley. The author suggests the existence of another channel, in this case draining southwards, buried under the broad area of Boulder-clay and gravel which lies immediately south of Stevenage and to the north as far as Letchworth and Wilbury Hill. But a narrow space of bare Chalk, at an elevation of 240 feet O.D. connecting large areas east and west of it, precludes the occurrence of a channel farther north than Letchworth.

II.—*January 8th*, 1908.—Sir Archibald Geikie, K.C.B., D.C.L., Sc.D., Sec. R.S., President, in the Chair.

The following communications were read:—

1. "Chronology of the Glacial Epoch in North America." By Professor George Frederick Wright, F.G.S.A. (Communicated by Professor E. J. Garwood, M.A., Sec. G.S.)

In the case of Plum Creek, Lorain County (Ohio), the study of the activity of the stream and of the amount of work which it has done since a certain stage of the Glacial epoch has yielded important results. This stream began the erosion of its trough when the temporary lake, held up in front of the ice, was maintained for a considerable period at the level of its Fort Wayne outlet; it has never had anything more resistant than Till to act upon. From a given section, 5,000 feet long, it has excavated 34 million cubic feet of Boulder-clay, removing it from exposed banks 1,600 feet long. Twelve years' erosion of a 500 foot length of a part of the trough of the stream under observation, and from banks 1,000 feet long, gives a rate of 8,450 cubic feet per annum. Therefore, the removal of 34 million cubic feet from the 5,000 foot section would give a period of 2,505 years. Considerations tending to lengthen the estimate are the former afforestation of the area and the increased gradient in the artificial cut-off. Those tending to shorten the estimate are the present wider flood-plain, the time taken for forests to grow, and the probably greater former water-flow.

The erosion of the Niagara Gorge began considerably later than that of Plum Creek, and probably dates from midway between the disappearance of the ice from Northern Ohio and from Quebec. If conditions have been uniform, the age of the Gorge would be 7,000

years. As the Niagara Limestone is thinner at the mouth of the Gorge, and the Clinton Limestone has dipped out of sight at the Whirlpool, there is nothing in the stratigraphy to indicate a slower recession in the past than in the present. Moreover, nearly one-third of the erosion has been accomplished by two pre-Glacial streams, one from the south and a smaller one from the north. Therefore the author concludes with considerable confidence that the Gorge is less than 10,000 years old, and that the ice of the Glacial epoch continued down to that time, to such an extent over the lower St. Lawrence Valley and Central New York that it obstructed the entire eastern drainage of the Great Lakes.

There is nothing which would lead to a longer estimate of the time which has elapsed since the Kansan stage of the Glacial epoch than that approved by Professor Calvin, of Iowa, and agreed to by Professor Winchell. These assume 8,000 years as the limit for post-Glacial time, and that a multiple of this by 20, amounting to 160,000, would carry us back to Kansan time. This, however, would still leave as long a period still earlier, for the advance of the ice. The author's impression is that the whole epoch may well have been compassed within 200,000 years.

2. "On the Application of Quantitative Methods to the Study of the Structure and History of Rocks." By Henry Clifton Sorby, LL.D., F.R.S., F.L.S., F.G.S.

The knowledge of the final velocities of material subsiding in water is of fundamental importance; but the relation between size of particles and velocity is complex, and perhaps may be partly explained by a thin, adherent film of water. The angle of rest in the case of sand-grains of varying size and quality enables us to ascertain approximately the velocity of current necessary to keep such sand drifting, and that needed to move it when at rest. The comparison of this angle with that observed in sedimentary rocks made of similar materials may be used to determine the amount of vertical contraction of rocks since deposition, the average in cases studied in Tertiary and Secondary rocks being from 100 to 57. In studying the drifting of sand along the bottom by currents (on which the author experimented in a small stream many years ago), the results are found to vary, according to whether the water is depositing sand as well as drifting it, and according to whether ripples are or are not being formed on the bottom. The velocity of a current can be determined approximately in feet per second for different kinds of sand. The connection between the structure of 'ripple-drift' and time is discussed; and an equation is given, from which the rate of deposit in inches per minute can be deduced. The connection between the structure of a deposit and depth of water is found to be difficult to study quantitatively. From the occurrence of 'drift-bedding' the depth of water may probably be determined to within a few feet, and on this being applied to particular rocks some interesting results come out, including the separation of sandstones into several different groups. The deposition of fine deposits, like clay, is a most complex subject, varying according to the amount of mud present in the water, and according to whether the grains subside separately or cohere together. When no pressure

is applied, even when no further contraction takes place on standing for a year, the amount of water included in the deposited clay may be 80 per cent., and when dry the minute empty spaces may still amount to 32 per cent. This leads to the conclusion that many of the older rocks must now be only 20 per cent. of their original thickness. In many cases there is produced by a gentle current a minute laminar structure from which probably the rate of deposition may be learned approximately, a common rate in the older rocks being from 9 to 18 inches per hour. But complex and difficult experiments are very desirable on this question. The rocks classed as clays differ very much in structure, and must have been formed under different conditions.

Applying these conclusions to various rocks, the author shows that in the green slates of Langdale there is good evidence that the volcanic eruptions sometimes occurred within a few weeks of one another, and at other times at more distant intervals. Now and then there were bottom currents, probably due to volcanic disturbances, gradually rising to a rate of about 1 foot per second and gradually subsiding, the entire period being a few minutes, and deposition taking place in different cases at from $\frac{1}{10}$ to 2 inches per minute. There is also good evidence that, when deposited, part of the rock was analogous to fine, loose sand, and part to semi-liquid mud. In the Coal-measure sandstones deposition at the rate of 1 inch per minute was common, with intervals of little or no deposit.

The volume of invisible cavities in rocks varies from 49 per cent. in some recent rocks to nearly 0 in the ancient slates. The packing of grains is discussed mathematically and experimentally, the latter with round and flattened shot; and experiments with sand of various qualities, rapidly deposited and also when well shaken, show a good agreement with calculation. The methods of determining the volume of minute cavities in rocks are given, followed by a number of examples from recent and older deposits. It is found that in some limestones the cavities have been reduced by pressure to close on the mathematical minimum, whereas in others, even of Silurian age, the cavities were filled with carbonate of lime, introduced from without, not long after deposition. Some oolites have had their cavities filled in a similar manner; in others most of the material of the original grain has been removed, and the present solidity is due to the filling up of the original cavities mainly by internal segregation. Among fine-grained rocks the Chalk probably was originally a sort of semi-liquid with fully 70 per cent. of its volume water, and in its present state is about 45 per cent. of its original thickness; the thickness of some clays must have diminished still more; while the amount of minute cavities in rocks with slaty cleavage is so small, that sometimes they are nearly solid.

By the measurement of green spots in slates it can be deduced that the rock before cleavage was somewhat more consolidated than rocks of the Coal-measures now are, and was then greatly compressed and the minute cavities almost completely squeezed up. The development of 'slip-surfaces' in cleaved rocks is very great, and furnishes an additional proof that the cleavage is of mechanical origin. 'Pressure-solution' is also dealt with.